# CHAPTER 5 – SECTION 508
# (Stone Matrix Asphalt)

This chapter outlines the required procedures and necessary documentation for designing stone matrix asphalt (SMA) for use on a DOTD project under Section 508 of the *Standard Specifications* (Stone Matrix Asphalt). It also details the responsibilities of the Certified Asphaltic Concrete Plant Technician (Quality Control), the DOTD Certified Asphaltic Concrete Plant Inspector, and the district laboratory. In addition, several other items are discussed pertaining to definition of lot size, SMA compaction/MTV requirements, and documentation/forms. SMA may be designed according to the Marshall Method (MS-2) or with the Superpave gyratory compactor.

SMA is a hot-mix asphalt consisting of two parts: a coarse aggregate skeleton and a binder-rich mortar. The rationale used in the SMA mix design is to first develop an aggregate skeleton with coarse aggregate-on-coarse-aggregate contact, generally referred to as stone-on-stone contact. The second part of the mix design rationale is to provide sufficient mortar (fines plus AC) of the appropriate consistency. Satisfactory mortar consistency requires a relatively high percentage of fines passing the No. 200 sieve (0.0075mm) and relatively high asphalt cement content. In order to achieve this mortar consistency, the VMA must exceed a minimum requirement of 16% for SMA. One potential construction problem with SMA is draindown of the asphalt cement from the aggregate matrix. Using a stiff asphalt cement binder will help to minimize any potential draindown problem. Mineral filler or fibers may be used to control draindown. The five steps required to obtain a satisfactory SMA mixture are:

1. Select proper aggregate materials.

2. Determine an aggregate gradation yielding stone-on-stone contact.

3. Ensure the chosen gradation meets or exceeds minimum VMA requirements.

4. Choose an asphalt content that provides the desired air void level.

5. Evaluate the moisture susceptibility and asphalt cement draindown.

## MIX DESIGN STEPS AND APPROVAL

Listed below are the general steps required to design, approve and validate an SMA mixture (Section 508).

- Material procurement and approval (fine aggregate, coarse aggregate, asphalt cement, anti-strip, mineral filler, and fibers)
- Gradation and Bulk Specific Gravity ($G_{sb}$) determination of aggregates
- Consensus aggregate tests (Fine Aggregate Angularity and Flat & Elongated Particles)
- Blending of aggregates to meet specified gradation
- Trial blends with varying asphalt cement contents

- Selection of optimum asphalt cement content
- Asphalt cement draindown evaluation
- Moisture sensitivity analysis
- Submittal process and Documentation – (JMF Release Form)
- Approval of JMF Release Submittal
- Validation of JMF Release Submittal
- Final Approval of JMF.

## 1 - Material Procurement and Approval

All samples are to be obtained in accordance with the requirements of the *Materials Sampling Manual*. A DOTD Sample Identification form (or an Aggregate Test Report form) must be completed for each material to be used (Appendix M and AY). Samples should be submitted at least three weeks prior to the submission of the job mix proposal (JMF). JMF submittals require 10 days for approval. No proposed JMF will be approved until all mix components have been sampled and approved.

**Coarse Aggregate -** Coarse aggregates for use in stone matrix asphalt shall be listed in QPL 2. This compilation lists all approved aggregates for use on DOTD projects along with their specific allowable use (hot-mix, concrete, etc.), friction rating, water absorption, Bulk Specific Gravity ($G_{sb}$), and Source Code

Coarse aggregate used in SMA shall be composed of clean and durable crushed stone. The combined aggregates shall be in accordance with the design gradation requirements in Table 508-1.

Subsection 1003.06(b) of the *Standard Specifications* requires that **50 percent of the coarse aggregates meet Class I friction requirements and the remainder meet Class I, II or III friction requirements. Alternately, 100 percent of the coarse aggregate shall meet Class II friction requirements**. At a 3 to 1 ratio in accordance with ASTM D 4791, the flat and elongated particle limit shall be 25 percent maximum by mass. In addition, at a 5 to 1 ratio, the flat and elongated particle limit shall be 5 percent maximum by mass.

**Fine Aggregate -** Fine aggregates for use in SMA, shall be from stone aggregate sources listed in QPL 2. Subsection 1003.06(b) of the *Standard Specifications* requires that the fine aggregate be comprised of 100 percent-crushed manufactured sand (i.e., screenings).

The Fine Aggregate Angularity (FAA) of each fine aggregate source shall be measured and the calculated fine aggregate blend (weighted average) shall be 45 percent minimum when tested in accordance with TR 121 (mineral filler excluded).

**Asphalt Cement -** Asphalt cement shall also be from an approved source listed in QPL 41. Asphalt cement grade shall be PG 76-22m. No substitutions are allowed for asphalt cement for SMA.

Asphalt cement is accepted at the plant, in addition to transport sampling, by a Certificate of Delivery (CD) (Appendix O). A Certificate of Delivery shall accompany each load delivered to the plant.

**Additives –** Anti-strip shall be added to all mixtures at a minimum rate of 0.5 percent by weight of asphalt and thoroughly mixed in-line with the asphalt cement at the plant. Anti-strip used shall be listed in QPL 57. Additional anti-strip may be added up to 1.2 percent by weight of asphalt cement. The rate listed on the proposed job mix formula (JMF) shall be 0.1 percent greater than the percentage that will yield a minimum tensile strength ratio (TSR) of 80 percent when tested in accordance with AASHTO T 283 with one freeze-thaw cycle. Therefore, the minimum rate that can be listed on the proposed JMF is 0.6 percent. A Certificate of Delivery shall accompany each load of anti-strip. (Appendix P)

Silicone additives, when needed, shall be from those listed in QPL 22. They shall be dispersed into the asphalt cement by methods and in concentrations given in the QPL. A Certificate of Delivery shall accompany each load of silicone additives.

Hydrated lime, if used, shall be from a source listed in QPL 34. The minimum rate shall not be less than 1.5 percent by weight of the total mixture. Further, hydrated lime shall be added to and thoroughly mixed with aggregates in accordance with Subsection 503.02(e). Hydrated lime may be also added as mineral filler. Each load of hydrated lime shall be accompanied by a Certificate of Delivery

Mineral filler, if used, shall be an approved product listed in QPL 10 and shall consist of limestone dust, pulverized hydrated lime (QPL 34), shell dust, Portland cement (QPL 7) or cement stack dust. Mineral dust collected in baghouses or by other dust collectors at asphalt plants is not classified as mineral filler. Mixtures of aggregate, filler and asphalt, in proportions to meet the requirements of mixes being used, shall have an index of retained Marshal Stability (TR 313) of at least 85 percent and a maximum of 1.0 percent volumetric swell (TR 313). Each load of mineral filler shall be accompanied by a Certificate of Delivery

Cellulose or mineral fibers, pre-approved by the Department, may be used to prevent draindown or to serve as a filler. The specific requirements for fibers are listed in Subsection 508.02.3(a) (Cellulose Fibers) and Subsection 580.02.3(b) (Mineral Fibers).

## 2 – Aggregate Bulk Specific Gravity ($G_{sb}$) and Gradation

**Bulk Specific Gravity ($G_{sb}$)** – Once proposed aggregate materials have been stockpiled at the plant and are approved for use (listed in QPL 2 for coarse aggregate and fine aggregate), the QC technician shall determine the bulk specific gravity of each mineral aggregate material. The QC technician and department inspector shall jointly obtain two samples for $G_{sb}$ determination from each proposed aggregate stockpile. The QC technician shall test one sample; the DOTD inspector will submit the other one, along with a Sample Identification Form, to the district laboratory.

AASHTO Test Procedure T 84 shall be used to determine $G_{sb}$ and absorption for each proposed fine aggregate source. Note that fine aggregate is defined in the *Standard Specifications* as all material passing the No. 4 sieve.

AASHTO Test Procedure T 85 shall be used to determine $G_{sb}$ and absorption for each proposed coarse aggregate source. Note that coarse aggregate, according to the *Standard Specifications*, is defined as all material retained on or above the No. 4 sieve. For coarse aggregates containing ten percent or less material by weight passing the No. 4 sieve, no $G_{sb}$ determination on that passing portion will be required. However, should the proposed coarse aggregate stockpile contain more than ten percent passing the No. 4 sieve, then that finer portion shall be separated (screened) and tested in accordance with AASHTO T 84. The two results, for both coarse and fine portions, shall then be mathematically combined in proportion to the amounts retained on the No. 4 and passing the No. 4 to produce a single $G_{sb}$ value for the source. The $G_{sb}$ is used to calculate VMA and asphalt absorption. False high values for $G_{sb}$ will lead to high VMA's and negative absorptions. If negative absorptions are calculated, the $G_{sb}$ is in error and the QC technician shall notify the district laboratory engineer.

The QC technician may use the calculated values for bulk specific gravity and water absorption on the proposed JMF, provided that they are within the range specified the table below. These values were determined from multi-laboratory precision analysis.

| **Multi-laboratory Precision for Bulk Specific Gravity ($G_{sb}$)** | |
|---|---|
| | **$G_{sb}$** |
| Fine Aggregate – T84 | ±0.035 |
| Coarse Aggregate – T85 | ±0.020 |

Should the contractor's values be outside this range when compared to the district laboratory, then two both parties shall jointly run a third test, the results of which shall be used for volumetric calculations on the proposed JMF submittal.

Bulk specific gravity values agreed upon by this procedure may be used on subsequent job mix formula submittals. However, the $G_{sb}$ may be retested at the request of either party. If $G_{sb}$ results are within the tolerances shown in the appropriate test procedure, as compared to the previously determined values, then the QC technician has the option of either using the new values or the previously agreed upon ones for which JMF's have already been approved and validated.

At the option of the QC technician or DOTD, if the proposed composite aggregate blend is already known, bulk specific gravity may be performed on a composite belt sample, separating the fine and coarse portions, in lieu of performing the $G_{sb}$ procedure on each individual aggregate component.

**NOTE**

RAP is not allowed in SMA.

**Gradation** – The QC technician shall obtain a second sample from each proposed stockpile for gradation determination. An accurate gradation analysis is required for blending analysis and to determine consistency of incoming material.

It is recommended that the QC technician secure samples of all bulk shipments of aggregates delivered to the plant site. The gradation results of these shipments should be determined prior to addition to a working stockpile. Further, documentation of these continuous stockpile gradation and specific gravity results should be kept on file so that varying trends of the aggregate source may be determined.

Under Subsection 109.07 of the *Standard Specifications*, the department may allow advanced payment to a producer for stockpiled materials stored in excess of 90 calendar days for use on a DOTD project. When requested by the contractor/producer, a written detailed description of the material, its intended use and location shall be provided to the project engineer. Refer to the section on Dedicated Stockpiles in this manual.

When inspecting and testing aggregates, a certified technician should be cognizant of proper bulk material handling. Quality control of hot-mix asphalt, regardless of plant type, begins with proper stockpile management. Aggregates must be handled in a manner that will not be detrimental to the final mixture. Stockpiles shall be built in a manner that will not cause segregation. Segregation can be minimized if stockpiles are built in successive layers, not in a conical shape. Constructing stockpiles in layers enables different aggregate fractions to remain evenly mixed and reduces the tendency of large aggregates to roll to the outside and bottom of the pile. Stockpiles shall be located on a clean, stable, well-drained surface to ensure uniform moisture content throughout the stockpile. The area in which the stockpiles are located shall be large enough for the stockpiles to be separated, so that no intermixing of materials will occur. Stockpiles shall not become contaminated with deleterious materials such as clay balls, leaves, sticks or nonspecification aggregates. Care shall be exercised not to segregate or contaminate the materials when moving aggregates from stockpiles to cold bins. Aggregates are often moved from stockpile to cold bin with a front-end loader. The operator should proceed directly into the stockpile, load the bucket and move directly out. He should not scoop aggregate from only the outside edges of the stockpile.

## 3 – Blending Aggregates to Meet Specified Gradation

Following bulk specific gravity determinations, gradation and FAA analysis, the technician must determine a master composite blend of the proposed aggregates. The specific gradation requirements for SMA are listed in the SMA Master Gradation table.

| SMA Master Gradation | | |
|---|---|---|
| **Sieve Size** | **Percent Passing** | **JMF Tolerance, %** |
| ¾ inch | 100 | ± 4 |
| ½ inch | 90 – 100 | ± 4 |
| 3/8 inch | 75 max | ± 4 |
| No. 4 | 24 – 34 | ± 4 |
| No. 8 | 16 – 28 | ± 4 |
| No. 30 | 12 – 25 | ± 3 |
| No. 50 | 11 – 22 | ± 3 |
| No. 200 | 7 – 13 | ± 1 |

Note that SMA is specified to be a ½-inch nominal maximum size mixture. Nominal maximum size and maximum size are defined below:

- **Nominal Maximum Size (NMS) – One sieve size larger than the first sieve to retain more than 10 percent by weight of the combined aggregates.**

- **Maximum Size (MS)– One sieve size larger than the nominal maximum size.**

The QC technician, knowing individual source gradations, can mathematically combine the materials to meet the composite gradation specification. Specific care should be given to provide for sufficient void space for adequate VMA.

Once the aggregates have been mathematically blended to meet requirements of Subsection 508.1, the composite gradation is plotted on the appropriate *Asphaltic Concrete Gradation – 0.45 Power Curve* for the ½-inch nominal maximum aggregate size (Appendix R). The "0.45 power curve" chart uses a unique graphing technique to show the cumulative particle size distribution of an aggregate blend.

Following is an example of the gradation requirements and a typical proposed composite SMA gradation (1/2-inch NMS).

| Sieve Size | Percent Passing | Mix Tolerance | Proposed JMF | JMF Limits |
|---|---|---|---|---|
| ¾ inch | 100 | ± 4 | 100 | 100 |
| ½ inch | 90 – 100 | ± 4 | 94 | 90 – 98 |
| 3/8 inch | 75 max | ± 4 | 73 | 69 – 75 |
| No. 04 | 24 – 34 | ± 4 | 30 | 26 – 34 |
| No. 08 | 16 – 28 | ± 4 | 22 | 18 – 26 |
| No. 30 | 12 – 25 | ± 3 | 18 | 15 – 21 |
| No. 50 | 11 – 22 | ± 3 | 19 | 16 – 22 |
| No. 200 | 7 - 13 | ± 1 | 8.6 | 7.6 – 9.6 |

Note that when the Mix Tolerances are applied to the Proposed JMF to determine the JMF Limits, a value cannot be reported that would be outside of the Control Points. For example, the 3/8-inch sieve has an upper JMF limit of 75 not 77, which would be outside the master grading for SMA.

All values are reported, for gradation purposes, to the nearest whole number with the exception of the Number 200 sieve size, which is rounded to the nearest tenth.

## 4 – Trial Blends with Varying Asphalt Cement Contents

The QC Technician, following determination of the composite aggregate blend, will prepare trial blends of hot-mix asphalt with varying percentages of asphalt cement. These trial blends may be produced either in the design laboratory or the HMA plant. (Remember only hot-mix produced from a certified plant and with an approved JMF will be allowed on a DOTD project.)

Subsection 508.02(a) of the *Standard* Specifications requires that PG 76-22m be used for all SMA's.

Three trial blends, at a minimum, shall be prepared with the proposed composite aggregate blend. One of the blends shall be prepared at an asphalt cement content near optimum (as defined by a specified air void content, $V_a$). A second trial blend shall be prepared at an asphalt cement content approximately 0.5% less than optimum. And, a third trial blend shall be prepared at an asphalt cement content approximately 0.5% greater than optimum. A minimum of two specimens shall be prepared at each of the trial asphalt cement contents.

The mixing and compaction temperature, used for preparing the trial mixes, shall be determined by the supplying asphalt cement supplier and will be printed on the certificate which accompanies each transport of asphalt cement delivered to the plant. (The traditional method of determining asphalt cement mixing and compaction temperatures, via a temperature and viscosity chart, is not valid for many of the polymer-modified asphalts now in use.)

**Unless procedures require otherwise, the laboratory produced mix shall be cured 2 hours in the mold and plant produced mix shall be cured 1 hour in the mold at the compaction temperature (±10°F). When the aggregate water absorption is >2%, the oven aging time for plant -produced mix shall be increased to 2 hours.**

The trial blends may be prepared and compacted according to one of the two allowed procedures (Subsection 508.03):

1. **Marshall Design** – The mixture shall be designed volumetrically in accordance with AASHTO R 12 (Asphalt Institute MS-2) using a **75 blow Marshall Design** with optimum asphalt cement content selected at **4.0 percent air voids**. The SMA mixture shall exhibit a minimum of **16.0 percent VMA** in design and shall maintain a minimum average 16.0 percent VMA for each lot during production.

2. **Superpave Gyratory Compactor Design** – The QC technician may use the Superpave gyratory compactor to design the SMA in accordance with AASHTO PP 28 with the following modification. **One hundred (100), ($N_{design} = N_{max}$)**, revolutions of the gyratory compactor will be required. $N_{initial}$ shall be less than 89 percent of $G_{mm}$ at 9 revolutions and the density at 100 revolutions shall be 96.0 percent of $G_{mm,}$ or 4 percent $V_a$. The mixture shall exhibit a minimum of 16.0 percent VMA in design and shall maintain a minimum average of 16.0 percent VMA for each lot during production. Superpave volumetrics shall be utilized in plant control when the Superpave gyratory compactor is used in design.

Each specimen (briquette) prepared for each trial blend shall be tested for the following:

**Marshall Design (AASHTO R 12):**

Bulk Specific Gravity, $G_{mb}$
Air Voids, $V_a$
Voids in Mineral Aggregate, VMA
Voids Filled with Asphalt, VFA
Marshall Stability

**Superpave Gyratory Compactor Design (AASHTO PP 28):**

Bulk Specific Gravity, $G_{mb}$

Air Voids, $V_a$
Voids in Mineral Aggregate, VMA
Voids Filled with Asphalt, VFA
Percent $G_{mm}$ at $N_{initial}$
Percent $G_{mm}$ at $N_{design}$

In addition, the QC technician shall prepare a loose mix sample at each trial blend asphalt cement content shall and test them for maximum theoretical specific gravity, $G_{mm}$ (Rice Gravity), using AASHTO T209. **For laboratory produced trial blends, the mixture when tested for $G_{mm}$, shall be cured at compaction temperature for approximately two hours prior to specimen preparation. Plant produced trial blends require one hour curing or aging period.** The average of the test values of two replicate specimens at each asphalt content shall be averaged to report a single value.

## SMA TERMINOLOGY

When analyzing and documenting SMA mixtures, the department uses the following definitions. Mineral aggregate is porous and can absorb water and asphalt to a variable degree. Additionally, the ratio of water to asphalt absorption varies with each aggregate. The three methods of measuring aggregate specific gravity take these variations into consideration. The methods published in ASTM C 127 and C 128 are bulk, apparent and effective specific gravities. The differences among the specific gravities come from different definitions of aggregate volume.

- Bulk Specific Gravity, $G_{sb}$ – The ratio of the weight in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 5-1.

- Apparent Specific Gravity, $G_{sa}$ – The ratio of the weight in air of a unit volume of an impermeable material at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 5-1.

- Effective Specific Gravity, $G_{se}$ – The ratio of the weight in air of a unit volume of a permeable material (excluding voids permeable to asphalt) at a stated temperature to the weight in air of equal density of an equal volume of gas-free distilled water at a stated temperature. See Figure 5-1.

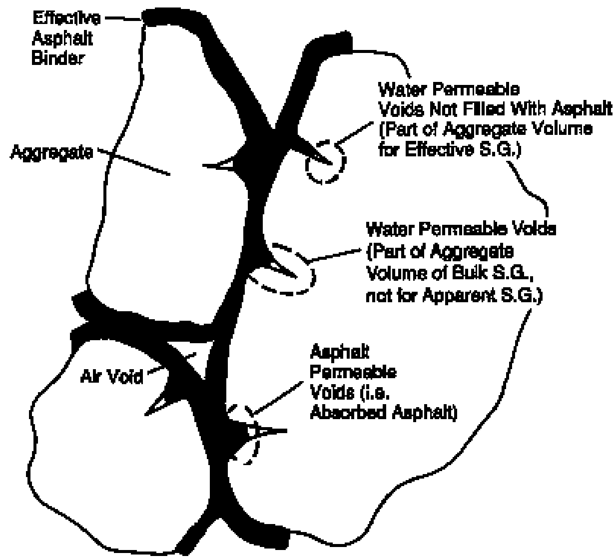


**Figure 5-1 – Illustrating Bulk, Effective and Apparent Specific Gravities, Air Voids and Effective Asphalt Content in Compacted Asphalt Paving Mixture**

- Voids in Mineral Aggregate, VMA – The volume of intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective asphalt content, expressed as a percent of the total volume of the sample. See Figure 5-2.

- Air Voids, $V_a$ – The total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture. See Figure 5-2.

- Voids Filled with Asphalt, VFA – The portion of the volume of intergranular void space between the aggregate particles (VMA) that is occupied by the effective asphalt. See Figure 5-2.

- Effective Asphalt Content, $P_{be}$ – The total asphalt content of a paving mixture minus the portion of asphalt that is lost by absorption into the aggregate particles. See Figure 5-2.

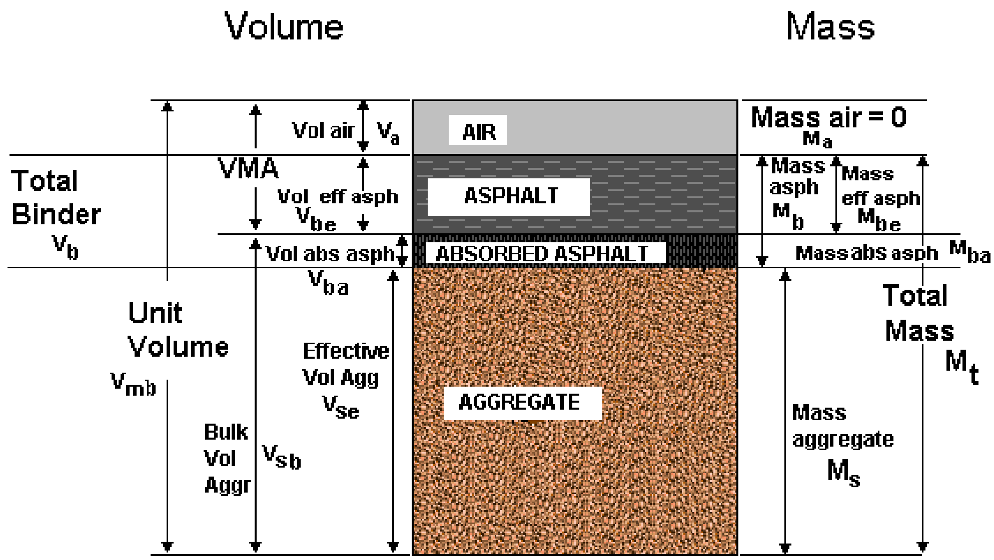


**Figure 5-2 – Representation of Volumes in a Compacted Asphalt Specimen (Phase Diagram)**

- Asphalt Cement Specific Gravity, $G_b$ – The ratio of the mass in the air of a given volume of asphalt binder to the mass of an equal volume of water, both at the same temperature.

- Mixture Bulk Specific Gravity, $G_{mb}$ – The ratio of the mass in air of a given volume of compacted HMA to the mass of an equal volume of water, both at the same temperature.

- Theoretical Maximum Specific Gravity, $G_{mm}$ (Rice Gravity) – The ratio of the mass of a given volume of HMA with no air voids to the mass of an equal volume of water, both at the same temperature.

- Initial Number of Gyrations, $N_{initial}$ - This is the number of gyrations (9 gyrations) that represents a measure of mixture compactability. Mixtures that compact too quickly are believed to be tender during construction and may be unstable when subjected to traffic. A mix that has 4 percent voids at $N_{design}$ should have at least 11 percent air voids at $N_{initial}$. Mixtures that tend to fail this requirement are often finer mixtures.

- Design Number of Gyrations, $N_{design}$ - This is the number of gyrations, 100 for SMA, required to produce a density in the mix that is equivalent to the expected density in the field after the indicated amount of traffic. In the mix design process, an asphalt content is selected that will provide 4 percent air voids when the mix is compacted to $N_{design}$ gyrations.

The following standard conventions are used to abbreviate asphalt cement (binder), aggregate, and mixture characteristics:

**Specific Gravity (G) – $G_{xy}$**

x - b = binder
s = aggregate (for example, stone)
m = mixture

y - b = bulk
e = effective
a = apparent
m = maximum theoretical

**Mass (P) or Volume (V) Concentration: $P_{xy}$ or $V_{xy}$**

x - b = binder
s = aggregate (for example, stone)
a = air

y - e = effective
a = absorbed

**SMA Definitions**

$G_{mb}$ = bulk specific gravity of the compacted HMA specimen.

$G_{mm}$ = maximum specific gravity of the paving mixture (no air voids)

$G_b$ = specific gravity of the asphalt

$G_{se}$ = effective specific gravity of the aggregate

$G_{sb}$ = bulk specific gravity of the aggregate

$V_a$ = air voids in the compacted mixture, percent of total volume

VMA = voids in the mineral aggregate, percent of bulk volume.

VFA = voids filled with asphalt, percent of VMA

$P_s$ = aggregate content, percent by total mass of the mixture

$P_b$ = asphalt content, percent by total mass of the mixture

$P_{ba}$ = absorbed asphalt, percent by mass of the aggregate

$P_{be}$ = effective asphalt content, percent by total mass of the mixture

$P_{200}$ /$P_{be}$ = dust to asphalt ratio

$P_{200}$ = aggregate content passing the N0. 200 sieve, percent by mass of aggregate

**The VMA values for compacted asphalt paving mixtures are to be calculated in terms of the aggregate's bulk specific gravity, $G_{sb}$.**

Voids in the mineral aggregate (VMA) and air voids ($V_a$) are expressed as percent by volume of the paving mixture. Voids filled with asphalt (VFA) is the percentage of VMA that is filled by the effective asphalt cement. The effective asphalt cement content shall be expressed as a **percent by weight of the total weight of the mixture.**

The following equations are used to compute the volumetric properties of compacted hot-mix asphalt specimens:

**Bulk Specific Gravity of HMA Specimen $G_{mb}$**

$$G_{mb} = \frac{\text{Weight in Air}}{\text{SSD Weight} - \text{Weight in Water}}$$

**Air Voids, $V_a$:**

$$V_a = 100 \times \frac{G_{mm} - G_{mb}}{G_{mb}}$$

**Voids in Mineral Aggregate, VMA:**

$$VMA = 100 - \frac{G_{mb} \times P_s}{G_{sb}}$$

**Voids Filled with Asphalt, VFA:**

$$VFA = 100 \times \frac{VMA - V_a}{VMA}$$

The SMA volumetric analysis results for the trial blends shall be documented on an approved computer generated spreadsheet or a similar DOTD supplied form or computer program.

The QC technician shall plot the following relationships, as determined from these equations, on the department's *Optimum Asphalt Cement Content Summary of Test Properties* or an approved similarly designed graph (Appendix U or AJ).

**Marshall Design (AASHTO R 12):**

Air Voids ($V_a$) versus asphalt content
Voids in Mineral Aggregate (VMA) versus asphalt content
Voids Filled with Asphalt (VFA) versus asphalt content
Marshall Stability versus asphalt content
Flow versus asphalt content

**Superpave Gyratory Compactor Design (AASHTO PP 28):**

Air Voids ($V_a$) versus asphalt content
Voids in Mineral Aggregate (VMA) versus asphalt content
Voids Filled with Asphalt (VFA) versus asphalt content
Percent $G_{mm}$ at $N_{initial}$ versus asphalt content

## 5 – Selection of Optimum Asphalt Cement Content

Examining the test property curves plotted on the department's *Optimum Asphalt Cement Content Summary of Test Properties*, reveals information about the sensitivity of the SMA mixture to asphalt content. Trends generally noted are:

- The percent air voids, $V_a$, steadily decreases with increasing asphalt cement content, ultimately approaching a minimum void content.
- The percent voids in the mineral aggregate, VMA, generally decreases to a minimum value then increases with increasing asphalt cement content.
- The percent voids filled with asphalt, VFA, steadily increases with increasing asphalt cement content because VMA is being filled with asphalt cement.
- For Marshall designs, the Marshall stability increases with increasing asphalt cement content up to a maximum, after which the stability decreases.
- For Marshall designs, the flow increases with increasing asphalt cement content.

**The design asphalt cement content of the mixture is the percent at the median percentage of the range of air voids (which is 4.0 percent for all SMA mixtures). The QC technician shall then evaluate all the calculated and measured mix properties at this asphalt cement content (particularly VMA) and compare them to the specified values in Table 508-1. If all of the design criteria are not met, then some adjustment is necessary or the mix may require redesign.**

The following information about VMA, $V_a$ and VFA will provide assistance and understanding to the technician in adjusting mixtures to meet these volumetric properties:

*EVALUATION OF VMA CURVE: In many cases, the most difficult mix design property to achieve is a minimum amount of voids in mineral aggregate. The goal is to furnish sufficient space for the asphalt cement so it can provide adequate adhesion to bind the aggregate particles, but without bleeding when temperatures rise and the asphalt expands. Normally, the curve exhibits a flattened U-Shape, decreasing to a minimum value and then increasing with increasing asphalt content.*

*This dependency of VMA on asphalt cement content appears to be a contradiction to the definition. One might expect the VMA to remain constant with varying asphalt cement content, thinking that the air voids would simply be displaced by asphalt cement. In reality, the total volume changes across the range of asphalt contents; the assumption of a constant unit volume is not accurate. With the increase in asphalt, the mixture actually becomes more workable and compacts more easily, meaning more weight can be compressed into less volume. Therefore, up to a point, the bulk density of the mixture increases and the VMA decreases.*

*At some point, as the asphalt cement content increases (the bottom of the U-Shaped curve) the VMA begins to increase because relatively more dense material (aggregate) is displaced and pushed apart by the less dense material (asphalt cement). It is recommended that **asphalt cement contents on the wet or right-hand increasing side of this VMA curve be avoided**, even if the minimum air void and VMA criteria are met. Design asphalt cement contents in this range have a tendency to bleed and/or exhibit plastic flow when placed in the field. Any amount of additional compaction from traffic leads to inadequate room for asphalt expansion, loss of aggregate-to-aggregate contact, and eventually, rutting and shoving in high traffic areas. Ideally, the design asphalt cement content should be selected slightly to the left of the low point of the VMA curve, provided none of the other mixture criteria are violated.*

*In some mixtures, the bottom of the U-Shaped VMA curve is very flat, meaning that the compacted mixture is not as sensitive to asphalt cement content in this range as some other factors. In the normal range of asphalt contents, compactability is influenced more by aggregate properties. However, at some point the quantity of asphalt will become critical to the behavior of the mixture and the effect of asphalt will dominate as the VMA increases drastically.*

*When the bottom of the U-Shaped VMA curve falls below the minimum criteria level required for the nominal maximum aggregate size of the mix, this is an indication that changes to the job-mix formula are necessary. Specifically the aggregate grading should be modified to provide additional VMA. **The design asphalt cement content should not be selected at the extremes of the acceptable range even though the***

***minimum criteria are met.*** *On the left-hand side, the mix would be too dry, prone to segregation, and would probably be too high in air voids. On the right-hand side, the mix would be expected to rut.*

*If the minimum VMA criteria is completely violated over the entire asphalt cement content range (curve is completely below the specified minimum), a significant redesign and/or change in material sources is warranted.*

*EFFECT OF AIR VOIDS: It should be emphasized that the design range of air voids (3 to 5 percent) is the level desired after several years of traffic. This goal does not vary with traffic; the laboratory compactive effort is supposed to be selected for the expected traffic. This design air void range will normally be achieved if the mixture is designed at the correct compactive effort and the percent air voids after construction is about 8 percent. Some consolidation with traffic is expected and desired.*

*The consequence of a change in any factor or any detour in the procedure that offsets the total process will be a loss of performance or service life. It has been shown that* ***mixtures that ultimately consolidate to less than three percent air voids can be expected to rut and shove*** *if placed in heavy traffic locations. Several factors may contribute to this occurrence; such as an arbitrary or accidental increase in asphalt cement content at the mixing facility or an increased amount of ultra-fine particles passing the No. 200 sieve beyond that used in the laboratory, which will act as an asphalt cement extender.*

*Similarly, problems can occur if the final air void content is above five percent or if the pavement is constructed with over eight percent air voids initially. Brittleness, premature cracking, raveling and stripping are all possible under these conditions.*

*The overall objective is to limit adjustments of the design asphalt cement content to less than 0.5 percent air voids from the median of the design criteria (4 percent for all SMA's), especially on the low side of the range and to verify that the plant mix closely resembles the laboratory mixture.*

*EFFECT OF VOIDS FILLED WITH ASPHALT: Although VFA, VMA and* $V_a$ *are all interrelated and only two of the values are necessary to solve for the other, including the VFA criteria helps prevent the design of mixes with marginally-acceptable VMA. The main effect of the VFA criteria is to limit maximum levels of VMA, and, subsequently, maximum levels of asphalt cement content.*

*VFA also restricts the allowable air void content for mixes that are near the minimum VMA criteria. Mixes designed for lower traffic volumes will not pass the VFA criteria with a relatively high percent air voids (five percent) even though the air void criteria range is met. The purpose is to avoid less durable mixtures in light traffic situations.*

*Mixtures designed for heavy traffic will not pass the VFA criteria with relatively low percent air voids (less than 3.5 percent) even though that amount of air voids is within the acceptable range. Because low air void contents can be very critical in terms of permanent deformation, the VFA criteria helps to avoid those mixes that would be susceptible to rutting in heavy traffic situations.*

*The VFA criteria provide an additional factor of safety in the design and construction process in terms of performance. Since changes can occur between the design stage and actual construction, an increased margin for error is desirable.*

## 6 – Asphalt Cement Draindown Evaluation

Asphalt draindown is another mixture requirement of Subsection 508.03(c). A **maximum 0.3 percent draindown** of asphalt cement by mass is allowed. ASTM D 6390 is used to determine the asphalt cement draindown.

## 7 – Moisture Sensitivity Analysis – Lottman Test (Tensile Strength Ratio)

To complete the design process, the QC technician shall perform the moisture sensitivity test (the Lottman – AASHTO T 283) to evaluate the proposed hot-mix asphalt blend for stripping. This test is not a performance-based test, but serves two purposes. First, it identifies whether a combination of asphalt binder and aggregate is moisture susceptible. Second, it measures the effectiveness of anti-stripping additives.

Subsection 508.03 requires that SMA mixtures yield a minimum TSR of 80 percent. In addition, the *Standard Specifications* require that the proposed JMF stipulate a single anti-strip rate, which is 0.1 percent greater than the percentage that will yield these TSR values up to a maximum of 1.2 percent. Appendix V depicts typical Lottman results and the form on which they are to be reported.

Once the department, according to Subsection 508.04, has approved the JMF, the mixture shall be validated for moisture sensitivity during JMF validation according to AASHTO T 283. This Lottman verification will be conducted in the plant laboratory during the first production lot. Results should be reported on the TSR Form (Appendix V) and forwarded to the district laboratory engineer with the JMF.

## 8 – Submittal Process and Documentation – JMF Release Form

Once the optimum asphalt cement content has been determined for the proposed aggregate blend, along with FAA tests, asphalt cement draindown evaluation and the moisture sensitivity analysis (Lottman test), the QC technician is prepared to submit the proposed job mix formula (JMF) to the district laboratory engineer. The JMF shall be submitted on a properly completed Asphaltic Concrete Job Mix Release Form (Y for

Marshall designs or AK for Superpave gyratory compactor designs) or an approved computer generated form similar to the one furnished by the DOTD.

Along with the Asphaltic Concrete Job Mix Release form, the QC technician shall submit the following information to the district laboratory engineer for approval.

1. A proposed blend summary with individual source and composite gradations and volumetric analysis at optimum asphalt cement content (Appendix Q for Marshall)

2. Bulk specific gravity, $G_{sb}$, of each aggregate and the combined bulk specific gravity for the mineral aggregate blend. Friction ratings.

3. A plot of the proposed composite gradation plotted to the 0.45 power with the gradation requirements. (Appendix R, S or T).

4. A quantitative summary of three (minimum) trial blends at optimum and ±0.5 percent asphalt cement along with volumetric calculations (Appendix U for Marshall or AO for Superpave).

5. Marshall Design - Optimum Asphalt Cement Content Summary of Test Properties (Appendix U) showing VMA, $V_a$, VFA and Marshall stability and flow versus asphalt cement content.

6. Superpave Gyratory Compactor Design - Optimum Asphalt Cement Content Summary of Test Properties (Appendix AP) showing VMA, $V_a$, VFA, percent $G_{mm}$ at $N_{initial}$ versus asphalt cement content.

7. Fine Aggregate Angularity (FAA) (AASHTO T 304) test results for the composite blend (Appendix AR).

8. Flat and Elongated Count (FE) test results for coarse aggregate retained on the No. 4, reported for both the 5 to 1 ratio and 3 to 1 ratio (Appendix AS).

9. Lottman results (from the laboratory or plant design) (Appendix V).

10. Draindown results

The QC technician shall submit the original and signed JMF Release, along with the supporting documents, to the district laboratory engineer for approval no less than 10 days before estimated production is to begin. **The district laboratory engineer must approve the proposed mix design before any mixture can be produced for the department.**

Upon approval of the proposed JMF, the district laboratory engineer will give it a numerical identification (the JMF Sequence Number). This identifying code must be clearly written, typed, or printed on the JMF Release Form and all supporting documentation.

## 9 – Approval of JMF Proposal

Upon approval of the JMF, the district laboratory engineer will sign the original in the Proposal Approved section at the bottom of the document and date it. The district laboratory will retain a copy and the original will be returned to the plant pending verification.

## 10 – Validation of JMF Release Submittal

Once the JMF has been approved for validation the plant may begin producing mixtures for the department according to the JMF. However, before the validation process begins for the approved JMF, the project engineer must verify that the mix type and project specifications for the project(s) receiving the mix are the same as the proposed mix design.

**It is the responsibility of the QC technician to provide the project engineer with a copy of the JMF prior to production for a particular project. (A facsimile copy will suffice.)**

JMF Validation will be completed on the first production sublot. It will be the evaluation to ensure that the mixture produced in the plant meets the tolerances set forth in the JMF Proposal.

The QC technician and DOTD inspector will perform JMF validation jointly on the first sublot (1000 tons).

Validation testing shall include:

- 1 – aggregate gradation
- 1 – percent asphalt cement
- 2 – briquettes tested for volumetrics ($V_a$ and VMA)
- 1 – asphalt cement draindown
- 1 – percent anti-strip additive
- 1 – moisture sensitivity (Lottman)
- 1 – Marshall Stability (when using Marshall Design)

In addition, a loose mix sample shall be analyzed for $G_{mm}$. One test, which is the average of two results, shall be run and used for volumetric calculations.

**All test results shall meet specification requirements for validation.**

**Upon validation of the JMF, the validation parameters shall be used for acceptance.**

The department will also evaluate the performance of the mixture on the roadway to ensure that the JMF is not contributing to laydown deficiencies, such as segregation, tenderness, workability, compactability, or surface texture problems. Mixtures that are identified as causing any laydown deficiency will not be approved. The project engineer, in charge of the project, or the district laboratory engineer may reject a proposed JMF due to roadway deficiencies.

If a mixture design fails to validate, a new proposal must be submitted and validation testing repeated. No mixture shall be produced for a DOTD project until the district laboratory engineer has approved a new JMF Release proposal, unless the producer uses a previously validated and approved JMF.

If the JMF does not validate, the district laboratory engineer will indicate disapproved on the proposed JMF Release, enter the sequence number, date, and sign it (Disapproved). Copies of the disapproved JMF Release will be distributed to each project engineer who received a portion of the lot.

Once completed, the validation data is promptly forwarded to the district laboratory engineer.

### 11 – Final Approval of JMF

The district laboratory engineer, upon receipt of the validated JMF, will sign and date the document for a second time on the Approved Line. Copies of the approved JMF will then be returned to the plant laboratory. Once a completed mixture design has been approved and validated, the same JMF may be used for all projects having the same specification requirements.

**It is the responsibility of the contractor/producer technician to provide the project engineer (in charge of a project anticipating receiving mix from the plant) with a copy of the Job Mix Formula (cover sheet only) prior to production (a facsimile will suffice).**

The district laboratory engineer will provide the contractor, producer, department plant personnel, and the project engineer who is receiving the mixture with an approved copy of the mixture design for project records.

## QC CERTIFIED TECHNICIAN – RESPONSIBILITIES

The primary responsibilities of the QC technician are to design hot-mix asphalt mixtures and control their production to ensure that they consistently meet department requirements.

The technician shall be at the plant for the beginning of daily operations. Whenever HMA mixtures are being produced for a DOTD project, the technician must be either at the plant or the paving site.

It is the certified technician's responsibility to perform all tasks necessary to begin plant operations. This includes, but is not limited to, checking asphalt cement working tanks, material stockpiles, aggregate bins, cold feed settings, meters and scales. The certified technician is responsible for recommending appropriate adjustments and ensuring that these adjustments have been made during continuing operations to ensure uniformity and conformance to specifications.

In addition, the certified technician shall oversee and monitor the complete production, transport, placement, and compaction phases to ensure compliance with minimum standards and to promote consistency. It is imperative that the technician use experience and common sense to analyze problem situations.

The certified technician shall be cognizant of proper plant operations and further aware of moisture inconsistencies. When the plant is put into operation, the technician shall monitor stockpiles to ensure that they are constructed properly and that moisture contents entered into the plant controls are consistent with actual values for each material bin.

Plant operation should be continuously inspected to ensure the following:

- Proper bag house operation (startup and shutdown loads will be impacted by improper sequence of fines return from the dust collection system producing material with inconsistent amounts passing the No. 200 sieve).

- Sufficient HMA is wasted at startup and shutdown to ensure adequate, sufficient, and consistent asphalt cement rates.

- Proper loading of trucks to minimize effects of material segregation.

Proper sampling is crucial for accurate results that represent actual plant production. The QC technician can take independent samples or can use unused quarters of samples taken by department personnel.

## Testing Frequency

Subsection 508.5 states that, for control purposes, the QC technician shall obtain one loose mixture sample taken from each sublot after placement of the mix in the truck and perform tests for extracted gradation (AASHTO T 30), asphalt cement content (TR 323), and $G_{mm}$ for each sublot (1000 tons). Note that one $G_{mm}$, which is the average of two test results, shall be determined from the one loose mix sample per sublot and the results averaged for use in determining volumetrics.

In addition to the above, the following samples, for quality control purposes, shall be prepared according to design type:

### Marshall Designs

A minimum of two briquettes shall be prepared per sublot and evaluated for $V_a$ and VMA. Also, the samples shall be tested for Marshall Stability and flow.

The average stability for a lot (an average of five sample for a five sublot lot) shall not be less than 1200 pounds and no individual sample shall be less than 800 pounds.

Control limits for $V_a$ shall be 3.0 to 5.0 percent.

The $G_{sb}$ of the combined aggregates shall be used to calculate the volumetrics.

**Superpave Gyratory Compactor Designs**

A minimum of two briquettes shall be prepared per sublot and evaluated for $V_a$ and VMA. Also, the samples shall be evaluated for percent $G_{mm}$ @ $N_{initial}$ and percent $G_{mm}$ @ $N_{design}$ (100 revolutions).

Control limits for $V_a$ shall be 3.0 to 5.0 percent at 100 revolutions.

The $G_{sb}$ of the combined aggregates shall be used to calculate the volumetrics.

This specified Quality Control Program is only a minimum requirement and should not prevent the technician from performing any test(s) in any frequency to ensure consistent materials, meeting specifications.

The QC technician should also, at regular intervals, check to ensure that the aggregate proportioning system is in calibration. This may be a two-step process. First, the weighbridge is checked, after plant production has ceased, to ensure that it is in calibration. This may be determined by running a known mass of material over it and correcting the weighbridge factor to get it into calibration over the full span of expected weights. Second, each feeder bin may be stopped, during normal operations, for 10 to 15 seconds, once the weighbridge has stabilized, to determine if the proper mass of material/per unit time is being proportioned from the individual bin. This type of quick check is typically referred to checking the calibration on the fly. However, this type of on the fly check is only accurate if it is known that the master weighbridge is in correct calibration.

There are other methods for checking cold feed calibrations such as that in DOTD's publication, *Cold Feed Adjustments for Asphaltic Concrete Plants*. In any method used, the measured weight of the aggregate includes moisture in the aggregate. Moisture content (M.C.) for each aggregate is calculated by the following equation:

$$\text{M.C.\%} = \frac{(\text{Wet Weight} - \text{Dry Weight})}{\text{Dry Weight}} \times 100$$

Therefore, to determine the *dry* mass, knowing moisture content, the following equation may be used:

$$\text{Total Dry Weight} = \frac{\text{Total Wet Weight} \times 100}{100 + \text{M.C.\%}}$$

All cold feed bins shall be provided with indicators to show the gate opening in inches. Further, each bin opening shall be rectangular, with one dimension adjustable by positive mechanized adjustment with a locking system.

Should the extracted gradation begin to fluctuate then the aggregate proportion system should be immediately checked along with individual stockpile gradations.

## Asphalt Cement Content

The asphalt cement content may be determined two ways. The ignition oven (TR 323) may be used along with a correction factor. Also, the rate of asphalt cement delivery is continuously shown, in digital form, on all modern plant controls. If these two values differ significantly then the correction factor for the Ignition Oven needs to be reevaluated or the plant asphalt cement metering systems needs to be recalibrated. The latter is done with a quantity of asphalt cement metered into a tanker or tank that can be readily weighed on a set of calibrated scales or load cells. Note that excess moisture in the mix may falsely appear as asphalt cement during the Ignition Oven test procedure and it may also artificially lower the $G_{mm}$ and artificially increase the Gmb. Higher asphalt content will also reduce $G_{mm}$.

## Laboratory Volumetrics

The QC technician shall conduct necessary quality control tests to ensure that volumetrics are within specification range. The sample of mixture taken from each sublot shall be evaluated for volumetrics. These values are shown along with other contractor/producer data on the QC copy of the Plant Worksheet (Appendix AB for Marshall or AW for Superpave).

## Additives

The QC technician shall also check the rate of anti-strip at the beginning of each operational period, and when necessary thereafter, to ensure that the mixture is receiving the JMF percent of anti-strip.

If used, the technician shall also check mineral filler, lime, or fibers at the beginning of each operational period, and when necessary thereafter, to ensure that the mixture is receiving the JMF percent of additive.

## Temperature

**Temperature of the asphalt cement and of the hot-mix asphalt is very critical. It is also critical that the temperature of these two products be as specified and consistent.**

Specific attention should be given to monitoring temperature in all asphalt cement working tanks and to ensure that all materials added, particularly from transports, are also at the correct elevated temperatures. Temperature is directly correlated with viscosity, which will affect the material's ability to adequately coat the aggregate.

Specifications require that a thermometer be provided to indicate mixture discharge temperature (typically at the discharge of the dryer/drum). Mixture temperature consistency is essential in obtaining consistent roadway compaction. The QC technician may check this thermocouple temperature against either an infrared gun-type thermometer device or by using a standard, calibrated dial thermometer.

The JMF stipulates an optimum mixing temperature range of ±25° F of the optimum mixing temperature for the asphalt cement used (supplied by the refinery). The discharge temperature shall always be within this range. Mixing temperature must never exceed 350°F at the point of discharge, regardless of the supplier's recommendations. Further, no mixtures shall be delivered to the paver cooler than ±25° F below the lower limit of the compaction temperature as shown on the JMF. (The temperature of the mix going through the paver shall not be cooler than 250° F.)

## Moisture

Stripping of asphalt courses will not occur in the absence of moisture or moisture vapor. To approach this ideal state, all hot-mix asphalt materials should be produced in a manner that minimizes internal moisture, which can weaken the molecular bond between the asphalt cement (binder) and the mineral aggregate.

However, with the average annual rainfall and humidity present in Louisiana, it is difficult to remove all free and absorbed moisture from aggregate in the HMA production process. In a typical plant, the heat generated from the fuel burned is transferred to the aggregate to evaporate moisture and heat the aggregate. As moisture in the aggregate evaporates, each pound of water expands to 33 cubic feet of steam. This enormous volume of steam must be removed by the plant's exhaust system. Hence, when aggregate moisture values increase (as in the presence of recent rainfall), the plant's production rate and burner settings must be adjusted to maintain and achieve consistent mixture temperatures and remove sufficient moisture. The drum mixer must also be routinely inspected for excessive flighting wear. Excessively worn or missing flights will greatly affect the plant's ability to heat and dry aggregates.

The presence of moisture also aggravates the process of accurately measuring mixture volumetrics. Excessive moisture in hot-mix asphalt may lead to an abrupt collapse in voids in mineral aggregate.

The certified technician, as part of the Quality Control plan, must continually monitor the moisture in the individual aggregate stockpiles (TR 403) and of the loose hot-mix asphalt (TR 319).

## Documentation

The QC technician shall keep, as a minimum, the following records on file at the plant laboratory:

1. An *Asphaltic Concrete Plant Report* form or *Superpave Asphaltic Concrete Plant Report* form (Appendix AB or AW) for each lot showing one (minimum) extracted asphalt content and gradation for each sublot. These gradations and asphalt cement contents results shall be entered on the QC copy of the Plant Report form.

2. The Plant Report form shall also show a single test value (minimum) of each for the following for each sublot:

   - Theoretical Specific Gravity ($G_{mm}$) – average of two
   - Air Voids ($V_a$)
   - Voids in Mineral Aggregate (VMA)
   - Marshall Stability – for Marshall designs
   - Percent $G_{mm}$ @ $N_{initial}$ - for Superpave Gyratory Compactor Designs
   - Percent $G_{mm}$ @ $N_{design}$ – for Superpave Gyratory Compactor Designs

3. Asphaltic Concrete Control Charts (Appendix AC).

For control purposes, the QC technician shall plot, per sublot, individual results for percent asphalt cement (TR 323), extracted gradation (TR 309), Air voids ($V_a$), and theoretical maximum specific gravity (T 209) on Asphalt Concrete Control Charts. The percent passing for each screen as indicated on the Job Mix Formula shall be entered in the field labeled "JMF ________%." The upper and lower limits for the JMF must be clearly shown on each graph. When the control charts show a trend in the mix toward the JMF limits, the QC technician shall immediately take steps to prevent the mix from moving outside the JMF limits. It is the department's intent that the mixture produced correspond to the JMF. Results that are within tolerances, but vary erratically within these tolerance limits, indicate that the plant is not producing a uniform mixture. If the control charts show that the mixture being produced is not uniform, the QC technician shall correct operations and produce a uniform mixture or discontinue operations for DOTD. When the results of two consecutive extracted gradation tests on any sieve fall within 1 percent of the approved JMF limit, the QC technician shall immediately make corrections to keep the mixture within specified limits. Failure to keep the mixture within specified limits shall result in the plant being prohibited from supplying this mixture to DOTD projects.

All corrections made by the QC technician to control the mixture and prevent any aspect of the mixture from moving outside specified limits, or from varying erratically within those limits, shall be documented on the back of the control chart. This documentation shall include the action taken, date and time, and be initialed by the QC technician. If the test results for any control chart cannot be plotted in the space provided on the control chart, the technician shall document the corrective action taken on the back of the chart. **The control charts shall be maintained per plant lot per job mix.**

The QC technician is to document all quality control (QC) testing and keep these records on file at the plant laboratory. The certified technician shall stamp all QC documents "QC" with red ink, in minimum one-inch high letters.

## DOTD CERTIFIED INSPECTOR - RESPONSIBILITIES

The DOTD certified inspector is the department's official representative at the plant. The DOTD certified inspector is responsible for the following:

1. Ensuring that the QC technician performs all tasks required
2. Checking the QC program (of the contractor/producer) to ensure that it is in conformance with department requirements
3. Ensuring that, through inspection, the HMA product meets all department standards.

The DOTD inspector is also responsible for ensuring that material samples required for department testing are obtained in accordance with prescribed testing schedules and frequencies, that all samples are representative of the material and that the samples are submitted, along with appropriate forms and documentation, to the appropriate testing facility in a timely manner. Additionally, the DOTD inspector is responsible for performing all acceptance sampling and acceptance tests on the product as delineated in this manual. During validation the DOTD inspector and QC technician may work together to perform sampling and testing to minimize tester variation. However, during production, the DOTD inspector must take and test acceptance samples.

Subsection 508.06 of the *Standard Specifications* outlines the required tests to be performed by the DOTD inspector for acceptability of the SMA. These tests are performed at the plant unless directed otherwise by the laboratory engineer. Sampling must follow a stratified sampling plan in accordance with the *Materials Sampling Manual* and specified test procedures. Random number tables were developed to ensure that sampling would occur at different times during production, and therefore, be representative of the mix. Since an inspector cannot always stop a test procedure to obtain a sample, some flexibility is allowed. These acceptance tests are listed below:

- Asphalt Cement Properties - Payment Factor Applied
- Percent Anti-Strip - Payment Factor Applied
- Air Voids, $V_a$ (at $N_{design}$ for Superpave) - Payment Factor Applied
- Voids in Mineral Aggregate, VMA (at $N_{design}$ for Superpave) - Payment Factor Applied
- Aggregate Gradation (No. 4 and No. 200 sieves) - Payment Factor Applied
- Pavement Density - Payment Factor Applied

- Surface Tolerance - Payment Factor Applied
- Asphalt Draindown
- Theoretical Maximum Specific Gravity, $G_{mm}$

Testing for surface tolerance (profilograph) will be required for each lot on the final roadway wearing course and airport wearing course lift. The DOTD Certified Roadway Inspector and the contractor's Authorized Profilograph Operator and Evaluator shall be responsible for the obtaining of these surface smoothness values.

## Asphalt Cement Properties – Payment Factor Applied

The DOTD inspector will sample and test shipments of asphalt cement in accordance with the requirements of Section 508 of the *Materials Sampling Manual*. Two samples, consisting of two one-quart friction top cans, shall be taken from each transport of asphalt cement delivered to the plant. Care should be taken to waste a sufficient amount of material in order to procure a representative sample and provide for safe sampling and handling of asphalt cement. These samples shall be clearly marked with the following:

1. Plant MATT Code, e.g., H312
2. Asphalt Cement Type
3. JMF Sequence Number
4. Sublot and Lot Number.

Appendix AF and AG show copies of the required asphalt cement and performance graded asphalt cement submittal forms; which shall accompany each sample of asphalt cement when submitted to the district laboratory.

One sample shall be tested at the district laboratory for Dynamic Shear (TP 5). Should this sample fail TP 5, the district laboratory will promptly notify the project engineer and the QC technician. The contractor shall notify the refinery.

Asphalt cement in the plant working tank must meet the specifications of the asphalt cement required on the JMF**.**

The DOTD inspector will document the metered AC content on the Superpave Plant Report. It should be noted that if the AC content from the meter or scales does not fall within ±0.1% of the optimum AC on the JMF, the DOTD inspector will immediately make a second determination. If these results indicate continued lack of conformance to the % AC requirements, the contractor/producer shall immediately discontinue operations for DOTD until the process has been corrected to the satisfaction of the district laboratory engineer.

## Percent Anti-Strip – Payment Factor Applied

An anti-strip additive shall be added to all mixtures at no less than the minimum rate determined in accordance with AASHTO T 283, at a rate not below 0.6 percent nor above 1.2 by weight of asphalt, in accordance with Subsection 508.03.

The DOTD inspector will test for the amount of anti-strip at a frequency of once per sublot. If the percentage of anti-strip added to the mixture is not in accordance with the minimum required on the JMF, a payment adjustment factor will be applied to the lot in accordance with Table 508-2 – Payment Adjustments Schedules for SMA. If the check performed indicates that the amount of anti-strip added is not in accordance with the JMF, the contractor must make adjustments so that the correct amount of anti-strip additive will be added to the mixture. If the second check indicates that the mixture is still not receiving the correct percentage of anti-strip, production for DOTD projects shall be terminated until adequate adjustments can be made to the system or the system can be recalibrated.

An example of applying payment adjustment factors for deficient anti-strip follows:

> Assume that the minimum percent anti-strip (%AS) that will yield 80 percent TSR, as determined by T 283, is 0.5 percent. Accordingly, the JMF then establishes 0.6% as the percentage of anti-strip to be incorporated in the mixture. Therefore the contractor/producer is allowed to operate between 0.5% to 0.7% anti-strip.
>
> Upon inspection, the DOTD's inspector checks the AS meter and determines that the mixture produced since the last check (573 tons) has received only 0.3%.
>
> The 573 tons produced at this percent anti-strip will cause an adjustment of the contract unit price for the sublot, in accordance with Table 508-2. The computation of this penalty is as follows:
>
> *The test indicated that the half-lot received only 0.3% AS, which results in 95 percent pay for that half-lot. The test for the second half lot indicated that the mix received 0.6% AS, which results in 100 % payment for the second half lot. Therefore, to calculate the payment adjustment for this lot:*

$$\text{Payment Adjusment} = \left( \frac{\%\ \text{payment for } 1^{st} \text{ half of lot} + \%\ \text{payment for } 2^{nd} \text{ of lot}}{2} \right)$$

$$\text{Payment Adjusment} = \left( \frac{95 + 100}{2} \right)$$

$$\text{Payment Adjusment} = 97.5 \text{ or } 98 \text{ percent}$$

The percent anti-strip shall be determined in this manner once per sublot. The percent payments for the individual sublot will be determined and then averaged for the lot to determine a percent pay for the entire lot for percent anti-strip additive.

**All projects receiving mixture from this lot will be assessed a payment adjustment for anti-strip, although this may not be the final percent pay for a project, since the plant volumetrics and gradation must also be considered. In addition, for roadway acceptance, the percent payment for pavement density and surface tolerance must be considered.**

The results of the percent anti-strip are entered on the Asphaltic Concrete Plant Report Form (Appendix AB or AW).

The basic method of checking the percentage of anti-strip in the mixture is to monitor the flow of additive for a continuous time sufficient to represent approximately half a sublot. In order to proceed with the calculations for the percentage of anti-strip, the technician must know the unit weight of the anti-strip additive at any given temperature. The anti-strip supplier must make the unit weight information available or a one-gallon sample may be weighed at the plant to determine this value.

An example of determining percentage of anti-strip added to HMA is as follows:

1. Read and record the temperature of the anti-strip additive being added to the mixture from the thermometer.

2. Take an initial reading of the amount of anti-strip additive from the anti-strip meter. Record the reading to the nearest readable increment (0.1 gallon or 0.25 gallon). Allow the plant to run for a continuous period of time sufficient to represent approximately half a lot. Take a final reading to the nearest readable increment and record.

3. Subtract the initial reading from the final reading to obtain the actual amount of anti-strip used during the time period.

4. Take an initial reading from the asphalt cement totalizing meter and record to the nearest gallon. (Some plants will digitally display the mass of asphalt cement added on the computerized operational controls.) Allow the plant to run for the same period of time as used for AS determination. Take a final reading of AC used and record to the nearest gallon. Subtract the initial reading from the final reading to obtain gallons AC used. **It is required that the percent asphalt cement and the percent anti-strip be checked simultaneously during continuous production to evaluate the quality of the mixture in terms of both components.**

Calculate the percent anti-strip in terms of the weight of asphalt cement in pounds.

$$\%\ \mathrm{AS} = \frac{\text{pounds of anti} - \text{strip}}{\text{pounds of asphalt cement} \times 100}$$

Calculate pounds of anti-strip:

| | |
|---|---|
| Unit weight of anti-strip | = 7.28 lb/gal (from curve) |
| Gallons anti-strip used during check | = 41.25 gal |

7.28 lb/gal x 41.45 gal = 300.3 lb

Calculate pounds of asphalt cement:

| | |
|---|---|
| Gallons AC used during check | = 5820 gal |
| Weight of 1 gallon of water | = 8.34 lb/gal |
| Specific Gravity of AC @ 60°F | = 1.03 |

5820 gal x 8.34 lb/gal x 1.03 = 49,994.964 lb

Calculate the percent anti-strip:

$$\% \text{ AS} = \frac{300.3}{49{,}994.964 \times 100}$$

= 0.600

= 0.6 % anti-strip

Report the final percentage of anti-strip additive to the nearest 0.1 percent.

If lime or another additive is being proportioned in the HMA mixture at the plant (and shown on the JMF), then this rate shall also be determined once per sublot, via the plant's meters/scales, and recorded on the QC copy of the *Asphaltic Concrete Plant Report* form (Appendix AB or AW).

## Air Voids ($V_a$) and Voids in Mineral Aggregate (VMA) – Payment Factor Applied

The DOTD inspector will test for Volumetrics ($V_a$ and VMA) at a rate of one test per sublot from samples taken randomly after the mixture is placed in trucks. One sample will be taken from each of the five sublots.

The DOTD inspector will prepare the samples (Marshall or gyratory briquettes) in accordance with AASHTO R 12 for Marshall designs or AASHTO TP 4, PP 19 and T 166 for Superpave Gyratory Compactor designs. The plant produced mixes shall be cured 1 hour (at compaction temperature) in the mold prior to compaction. Aggregates with water absorption greater than 2% will require 2-hour aging period.

After the briquettes have cooled to room temperature, the DOTD inspector will test the briquettes for specific gravity ($G_{mb}$) and compare the result to the theoretical maximum gravity ($G_{mm}$). The DOTD inspector will evaluate the samples for $V_a$ and VMA.

The DOTD inspector will compare the test results for volumetrics ($V_a$ and VMF) for each sublot to the JMF limits. If any results are out of the JMF limits, the QC technician shall immediately make corrections or discontinue operations for DOTD projects. The DOTD inspector will determine deviations from the JMF limits for each sublot in accordance with Table 508-1 – Stone Matrix Asphalt (SMA) Mix Properties. The average of the % deviations for each sublot are then used to compute % pay for $V_a$ and for VMA in accordance with Table 508-2 – Payment Adjustment Schedules.

An example of determining percent payment for $V_a$ and VMA follows:

Lot 105 – 5010 tons of SMA (1/2 inch NMS)

$V_a$ and VMA results for Lot 105:

| | **Sample 1** | **Sample 2** | **Sample 3** | **Sample 4** | **Sample 5** |
|---|---|---|---|---|---|
| **$V_a$** | 3.9 | 3.5 | 3.6 | 3.5 | 3.5 |
| **VMA** | 15.6 | 15.7 | 15.2 | 16.2 | 15.6 |

From Table 508-2 it can be seen that the $V_a$ for each of the five sublots is within the specified range of 3.0 to 5.0 percent (from Table 508-1). There were no deviations from JMF limits.

However, the VMA for the sublot 1 is 0.4 percent below the 16.0 minimum shown in Table 508-1. Additional deviations are as follows:

| | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Average |
|---|---|---|---|---|---|---|
| **VMA** | 15.6 | 15.7 | 15.2 | 16.2 | 15.6 | |
| **Deviations** | 0.4 | 0.3 | 0.8 | 0.0 | 0.4 | 0.4 |

Therefore, from the Payment Adjustment Schedules (Table 508-2), for an average deviation of 0.3 – 0.5, a payment of 95.0 percent would be applicable to Lot 105 for VMA results.

Although % pay has now been determined for Anti-strip, $V_a$, and Voids, the gradation must still be considered to determine total plant acceptance pay. **In addition, for roadway acceptance, the percent payment for pavement density and surface tolerance must be considered. The payment adjustment for asphalt cement properties will stand-alone and will not be used in the individual lot calculations for payment.**

## Gradation – Payment Factor Applied

The DOTD Certified Inspector, for the purpose of gradation acceptance testing (TR 323 and TR 113/112), will obtain one sample of the loose HMA mixture. One sample will be taken from each sublot. Sampling shall be in accordance with DOTD Designation S203 in the *Materials Sampling Manual*. The sample shall be divided into two portions. One verification sample shall be submitted to the district laboratory (one loose mix sample per sublot) and must be clearly labeled with the following:

1. Plant MATT Code, e.g., H312
2. Mix Type (i.e., SMA – 25)
3. JMF Sequence Number
4. Lot Number.

The DOTD inspector will perform gradation analysis on the other sample at a frequency of once per sublot.

This adjustment in unit price is determined by percent deviation from JMF control limits for the No. 4 and No. 200 sieve sizes.

An example of applying payment adjustment factors for extracted aggregate gradation follows:

Lot 105 – 5010 tons of SMA (1/2 inch NMS)

Gradation results (No. 4 and No. 200 sieves) for Lot 105:

JMF Limits for the No. 4 sieve are 26 – 34 percent and the JMF Limits for the No. 200 sieve 7.6 – 9.6 percent.

| | **Sample 1** | **Sample 2** | **Sample 3** | **Sample 4** | **Sample 5** |
|---|---|---|---|---|---|
| **No. 4** | 27 | 28 | 26 | 30 | 36 |
| **No. 200** | 8.3 | 7.9 | 8.6 | 8.6 | 8.9 |

For payment determination for gradation, the percent deviation for each sieve for each sublot from the JMF tolerances is calculated. The average of the sublot deviations is used to determine the percent payment for each sieve size.

From Table 508-2 it can be seen that the average deviations for the No. 4 and No. 200 sieves for the five sublots is within the specified ranges in Table 508-1 for full payment.

**To determine total plant pay, first average the % pay for these four items ($V_a$, VMA, Percent Passing the No. 4, and Percent Passing the No. 200). Compare this average percent pay to the percent pay for anti-strip determined previously. Use the lowest percent pay of the two to represent Plant Acceptance Pay.**

For example:

Antistrip: 97.5%

$V_a$: 100.0%
VMA: 95.0%
No. 4 Sieve: 100.0%
No. 200 Sieve: 100.0%

$$\text{Average} = \left( \frac{100 + 95 + 100 + 100}{4} \right)$$

$$\text{Average} = 98.8 \text{ percent}$$

Now compare the 97.5% pay of the anti-strip to the 98.8% pay of the four averaged parameters. Use the lowest, which is 97.5% pay.

**In addition, for roadway acceptance, the percent payment for pavement density and surface tolerance are averaged. Finally, the percent payment for the SMA lot will be the lowest value of the percent payments for plant acceptance and roadway acceptance. The payment adjustment for asphalt cement properties will stand-alone and will not be used in the individual lot calculations for payment.**

## Pavement Density

Upon completion of compaction procedures, contractor/producer personnel shall obtain five pavement samples from each portion of the plant sublot per mix use placed on a specific project. DOTD's certified paving inspector shall select sampling locations for pavement density cores by application of the Random Number Tables (DOTD S605). If a sampling location falls within one foot of an unsupported edge of the pavement, within 50 feet of a joint or structure, or within an obviously bad spot that is to be replaced, another sampling location shall be selected through the reapplication of the Random Number Table. The DOTD paving inspector, upon determination of the coring locations, will provide the contractor's coring representative with a list of the coring stations (with transverse dimensions). All cores shall be taken within 5 feet of the selected location according to this list.

The contractor shall fill and compact all core holes with asphaltic concrete or cold mix.

Samples shall be taken within 24 hours after placement of the mix, unless this deadline falls on a day that the contractor's crews are not working. In this case, samples shall be taken within 3 calendar days. For patching or widening operations, this time limit may be extended until the HMA has cooled sufficiently for coring to proceed.

The project sublot portion will be divided into five sections of approximately equal length; one sample shall be obtained from each sublot. Each portion of a sublot placed on a given project (per use) will always be represented by exactly five samples for pavement density testing, with the exception of small quantities and patching and widening operations.

Since pavement density must be compared to the theoretical maximum density ($G_{mm}$) for the lot, the core samples must be clearly identified by sublot and lot number. The date the samples are taken will be recorded on the Asphaltic Concrete Pavement Report

(Appendix AD). If the sample obtained from a pavement sublot is less than 1 3/8 inches thick, the DOTD Certified Paving Inspector will reject the core and select another sampling location for that sublot by re-application of the Random Number Tables. The official measurement of the core will be obtained by taking three measurements spaced uniformly around the circumference. These measurements will be taken to the nearest 1/8-inch. The average of these measurements will be considered the official measurement and will be recorded, by the DOTD Certified Inspector, to the nearest 0.01-inch on the Pavement Report (Appendix AD).

HMA mixtures placed in design layers less than 1 3/8 inches thick shall be compacted by approved methods to the satisfaction of the project engineer and shall not require coring.

Should a specimen be damaged during operations, the contractor/producer coring representative may move longitudinally up or down the pavement within five feet to procure another specimen.

The DOTD inspector will evaluate the five cored pavement samples for specific gravity test ($G_{mb}$) (AASHTO T 166), and compare, as a percentage, to the theoretical maximum specific gravity ($G_{mm}$) reported for the sublot. The DOTD inspector will average the percent $G_{mm}$ determined for each pavement sample to calculate an average density for the sublot. Specific attention should be given to ensure that the pavement cores are sufficiently free of moisture. This may include placement of the cores in a force draft oven at 125° F until a constant mass is attained in accordance with AASHTO T 166. Constant mass is defined as the mass at which further drying at 125° F does not alter the mass by more than 0.05 percent. **For permeable mixtures this error can be significant. Cores shall be handled according to Subsection 502.09.**

The Certified Paving Inspector, along with the contractor/producer coring representative, will inspect the cores for acceptability and label them for identification. The DOTD inspector and contractor/producer technician, upon inspection and mutual agreement, also reserve the right to reject any core(s). It is intended that cores be delivered to the plant on the same day as they are taken, so that the results for acceptance and verification can be made available to the project engineer and field compaction personnel in a timely manner.

The inspector will include with the original one copy of the Asphaltic Concrete Pavement Report (Appendix AD) and the Asphaltic Concrete Verification Report (Appendix AE) with the cores sent to the plant for testing.

For HMA patching and widening, the contractor shall take one sample per 200 tons (or less) up to a maximum of five samples for that portion of each sublot placed on a project. If the portion of a sublot that is delivered to a project extends beyond one day's production, a maximum of five samples will be tested for acceptance purposes. These five samples should be apportioned so that they proportionally represent the percentage of the lot placed on the project each day. Sampling and testing for density shall be of the top four inches of finished sections.

**Pavement density testing shall not be required for guardrail widening. In addition, pavement density requirements will not be applied to short irregular sections, in accordance with Subsection 502.12 of the *Standard Specifications*.**

Subsection 503.02 of the *Standard Specifications* requires that a plant laboratory, in order to comply with certification requirements, be equipped with a saw suitable for sawing HMA pavement cores. This saw may be used by the contractor/producer to reduce patching/widening cores to four inches, remove base course material (i.e., soil cement and/or curing membrane), or to make regular the geometry of the 4 or 6-inch diameter cylindrical sample.

**The percent payment for roadway density for each lot will be the average of the percent pay for each sublot.**

**For roadway acceptance, the percent payment for pavement density and surface tolerance are averaged. Finally, the percent payment for the SMA lot will be the lowest value of the percent payments for plant acceptance and roadway acceptance. The payment adjustment for asphalt cement properties will stand-alone and will not be used in the individual lot calculations for payment.**

Notes on the determination of the bulk specific gravity ($G_{mb}$) of a pavement core:

*Weighing an object (as we do with an HMA core) to determine its mass in air and its mass in a fluid (as we do in water) whose specific gravity is known yields sufficient data to determine its weight (mass), volume, and specific gravity. Specific gravity is defined as the ratio of the weight of a unit volume of the sample to the weight of an equal volume of water at approximately 25°C±1°C, (77°F±1.8°F).*

*LA DOTD now specifies that the $G_{mb}$ be determined by TR 304 (AASHTO T166). The equation for calculating $G_{mb}$ is as follows:*

$$G_{mb} = \frac{\text{Weight in Air}}{(\text{SSD Weight} - \text{Weight in Water})}$$

*As the size of the external voids in the specimen increases, it becomes difficult to determine an accurate SSD weight, because the diameter of the voids is of such size that the water will run out of them before an accurate SSD mass can be determined.*

*Additionally, an absorptive aggregate (whose cross-sectional area is exposed on a cored pavement specimen) will take on additional water, which in turn will produce an artificially high $G_{mb}$.*

*To account for these two phenomena AASHTO T 166 provides for an alternate test procedure (AASHTO T 275 – Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin) for determining $G_{mb}$ when the percent water absorbed by the specimen exceeds 2.0 percent when determined by the following equation:*

$$\text{Percent } H_2O \text{ Absorbed (by Volume)} = \frac{(\text{SSD Weight} - \text{Weight in Air})}{(\text{SSD Weight} - \text{Weight in Water})}$$

*In addition to AASHTO T 166 and T 275, there exist two other methods to determine $G_{mb}$ of a cored pavement specimen. One method, the Pure Volume method, is conducted by measuring the thickness and diameter of the cylindrical specimen in numerous locations to calculate average values and then using the following formula to determine its volume:*

$$\text{Volume} = \pi \text{ x} \left(\frac{\text{Diameter}}{2}\right)^2 \text{ x Height}$$

*This volume is used in the denominator with dry weight in air, in the numerator, to determine the $G_{mb}$.*

*The second method, which uses proprietary equipment, involves weighing the submerged specimen in a vacuumed plastic bag to determine a true volume.*

*In summary, if the contractor/producer technician or the DOTD inspector suspects that $G_{mb}$ values determined via AASHTO T 166, in the field laboratory, are yielding erroneous values the district laboratory engineer should be notified.*

**NOTE**

AASHTO T 275 and the pure volume method are not approved DOTD test methods. Results obtained from these procedures are informational only.

## Surface Tolerance Requirements

The contractor/producer shall provide an approved 25-foot California-Type Ames Profilograph calibrated and operated in accordance with DOTD TR 641 for longitudinal surface tolerance quality control and acceptance testing. (The contractor may elect to use alternate or automated profilographs in lieu of the standard specified profilograph for Quality Control with the approval of the Materials Engineer Administrator.)

Quality control test results have the same requirements as acceptance test results. The QC trace may be used for project acceptance, providing the DOTD inspector accompanies the profilograph operator and takes immediate possession of the trace upon completion of the quality control evaluation. Acceptance testing is required in both wheel paths.

The operation of the profilograph, including evaluation of the profile trace, determination of the Profile Index, calculation of the Average Profile Index and the determination of high points (bumps) in excess of specification limits shall be performed by a trained, authorized technician who has successfully completed the department's training and evaluation program for Profilograph Operator and/or Profilograph Evaluator.

Surface tolerance testing will be required on roadway travel lanes and airport wearing (one pass on either side of the runway centerline) and binder courses, and shoulder and parking area wearing courses. For the purposes of surface tolerance requirements, the wearing course is defined as the last lift placed. The binder course is defined as the last lift placed prior to the wearing course.

Other lifts on which additional HMA is to be placed shall be finished so that succeeding courses will meet the specification requirements.

The finished surface will be tested in the longitudinal direction for conformance to the surface tolerance requirements listed in Table 502-7. When testing for roadway travel lanes and airport wearing and binder courses using the profilograph, both wheel paths in each paving strip in a lot will be selected for Quality Control and Acceptance Testing.

The contractor shall test the pavement during the first workday following placement, but in no case later than 14 calendar days. Profilograph operations should be scheduled to reduce traffic congestion around an on-going paving operation/train.

When QC testing establishes that the surface tolerance is deficient, the contractor shall immediately suspend paving operations. Paving operations will not be allowed to resume until appropriate corrections have been made and a test section successfully placed with acceptable surface tolerance. This test section shall consist of a maximum of 500 tons of HMA placed in a continuous operation.

The contractor shall correct deficiencies determined during quality control testing. These deficiencies shall be corrected in the final wearing course by diamond grinding and applying a light tack coat, or removing and replacing, or furnishing and placing a supplemental layer of wearing course mixture at least 1 ½ inches of compacted thickness for the full width of the roadway at no direct pay. Deficiencies to be corrected in binder courses shall be corrected by diamond grinding or other suitable means to meet specification requirements.

After the contractor has completed quality control testing and any required corrective work, the department will evaluate the profile trace from the contractor's quality control tests. Longitudinal variations in the final wearing course surface will be subject to provisions in Table 501-5 Payment Adjustment Schedules. The contractor will be allowed to evaluate the final quality control trace to determine if any corrective measures are needed to eliminate deficient areas. Upon completion of the contractor's evaluation, the DOTD inspector will take possession of the final quality control trace to be used for project acceptance. Following correction of deficiencies, it will be necessary to reprofile those affected areas and recompute the profilograph index using the original trace and the reroll traces. The department reserves the right to conduct independent acceptance tests.

The surface of each shoulder will be tested longitudinally by the engineer at a minimum of one randomly selected location of each 300 linear feet of shoulder using the 10-foot metal static straightedge; areas with surface deviations in excess of ½ inch will be isolated by the engineer and shall be corrected by the contractor.

Excessive rippling of the mat surface will not be accepted. Ripples are small bumps in the pavement surface, which usually appear in groups in a frequent and regular manner.

Specifically, a ripple is visible on the profile trace, but does not appear above or below the 0.2-inch (5 mm) blanking band required by DOTD TR 641. There shall be no more than 12 ripples or peaks in any 100-foot (30-m) section. Rippling indicates a problem with the paving operation or the mix that requires immediate correction by the contractor. Otherwise, the contractor shall cease operations. The contractor shall correct unacceptable areas at no direct pay.

**Surface tolerance requirements will not be applied to short irregular sections, in accordance with Subsection 502.12 of the *Standard Specifications*.**

For transverse and longitudinal surface tolerance acceptance testing, the contractor shall also furnish a minimum 10-foot metal static straightedge.

**Transverse Surface Tolerance -** The transverse surface finish shall be controlled so that the values shown in Table 501-3 will not be exceeded.

**Cross Slope Tolerance -** When the plans require the section to be constructed to a specified cross slope, tests shall be run at selected locations using a stringline, slope board or other comparable methods. The cross slope shall be controlled so that the values shown in Table 501-3 will not be exceeded. Cross slope variation allowed in Table 501-3 shall be apply to each lane constructed.

**Grade Tolerance -** When the plans require the pavement to be constructed on a grade, tests for conformance shall be performed at selected locations using a stringline or other comparable method. Grade variations shall be controlled so that the tolerance shown in Table 501-3 will not be exceeded. Grade tolerances shall apply to only one longitudinal line, such as the centerline or outside edge of pavement.

| Surface Tolerance Variation | Transverse | Cross-Slope | Grade |
|---|---|---|---|
| Roadway Travel Lane Wearing Courses | 1/8 inch | 3/8 inch | ½ inch |
| Binder Course | ¼ inch | ½ inch | ½ inch |
| Shoulder Wearing Course | 3/16 inch | ¾ inch | ¾ inch |

Transverse and Cross Slope are based on 10 feet.
Grade is applicable only when specified.

The project engineer will review the profile trace obtained for each binder and wearing course on a per lot basis. In special cases or extenuating circumstances, the engineer may isolate sections of the profile trace that are out of specification. These sections may be excluded from the calculations of the Average Profile Index. These special cases or extenuating circumstances may include curb and gutter sections that require the adjustment of cross-slope in order to maintain adequate drainage, manholes, catch basins, valve and junction boxes, street intersections, or other structures located in the roadway that will cause abrupt deviations in the profile trace. High points in excess of 0.3 inch in 25 feet shall be corrected, unless in the opinion of the engineer, these high points do not cause damage to the roadway section or rideability. These high points then may be allowed to remain with a $500.00 per bump rebate. In all cases, the contractor has the option to grind the bumps to meet the specifications. The exclusion comments mentioned in this paragraph do not apply to multi-lift new construction and overlays with more than two lifts.

**Dimensional Requirements** (for mixtures specified on a cubic yard basis) – Overthickness and overwidth will be waived at no direct pay.

Underthickness shall not exceed ¼ inch when determined in accordance with TR 602. For the final wearing course, areas with underthickness in excess of the ¼ inch shall be corrected to plan thickness at no direct pay. Corrective measures shall require furnishing and placing a supplemental layer of wearing course mixture meeting specification requirements over the entire area for the full width of the roadway when grade adjustments are permitted. When grade adjustments do not permit, the deficient under thickness area shall be removed and replaced at no direct pay.

The contractor shall correct underwidths, as determined in accordance with TR 602, by furnishing and placing additional mixture one foot wide and plan thickness at no direct pay.

**Asphalt Cement Draindown** – The DOTD inspector will test for asphalt cement draindown once per lot (minimum). A maximum 0.3 percent draindown of asphalt cement by mass will be allowed.

**Theoretical Maximum Specific Gravity, $G_{mm}$** – The DOTD inspector will determine the theoretical maximum specific gravity**,** $G_{mm}$ in accordance with AASHTO T 209. The reported value shall be determined from the average of two tests performed on the loose mix sample used for volumetric analysis.

## DOTD DISTRICT LABORATORY – VERIFICATION RESPONSIBILITIES

The district laboratory performs verification testing to ensure that contractor/producer and DOTD personnel are using correct and accurate procedures, as well as proper equipment.

For SMA materials, the following verification tests are performed:

| Sample | Tests | Frequency |
|---|---|---|
| Briquettes | Volumetrics | 1 per lot |
| Pavement Cores | Density | 2 per lot |
| Loose Mix Sample | Gradation | 1 per lot |

Verification samples must be delivered to the district laboratory in a timely manner so that the department and the QC technician may study the total quality control process and be assured that the results of sampling and testing used for acceptance and control are valid and representative of the material.

The results of verification testing for HMA materials should be within the tolerances provided in the following table:

| Test | Tolerance |
|---|---|

| | |
|---|---|
| Pavement Core | ± 0.7% of pavement density |
| $V_a$ | ± 1.0% plant test results |
| VMA | ± 0.5% plant test results |
| Gradation | ≥No. 4: ±5%; <No. 4 ±2 |

If the results of verification tests are outside of these tolerances or the limits of the specifications, then the district laboratory engineer will notify the plant immediately. He will then follow up with a written notice of the discrepancy to the project engineer. It will be the joint responsibility of the project engineer and the district laboratory engineer to investigate the problem and, if necessary, to inspect both the process and testing equipment and the actual testing procedures in use at the plant, followed by a notice of discrepancy when necessary.

In addition, as previously described, the district laboratory will perform acceptance and verification analysis on asphalt cement.

## EXAMPLE SUMMARY – APPLICATION OF PAYMENT ADJUSTMENTS

For the purposes of this example, it will be assumed that all test results and inspection procedures not covered by payment adjustments have met the requirements of applicable specifications.

Lot 105 = 5010 tons of SMA (1/2-inch NMS)

**Plant Acceptance**

- Percent anti-strip 100.0 percent
- $V_a$ 100.0 percent
- VMA 95.0 percent
- No. 4 sieve 100.0 percent
- No. 200 sieve 100.0 percent

Therefore, the percent payment for plant acceptance is the lowest value between the average of $V_a$, VMA, No. 4 sieve and No. 200 sieve ((100+95+100+100)/4 = 98.8 percent pay) and percent anti-strip, 100.0%. In this example, the percent payment for the plant is 98.8 percent

**Roadway Acceptance**

- Pavement Density

| | | |
|---|---|---|
| Sublot 105-A | 100.0 | percent |
| Sublot 105-B | 100.0 | percent |
| Sublot 105-C | 95.0 | percent |
| Sublot 105-D | 80.0 | percent |
| Sublot 105-E | 100.0 | percent |
| Average | 95.0 | percent |

- Surface Tolerance 100.0 percent

Therefore, the percent payment for roadway acceptance is the average of the percent payments for pavement density and surface tolerance:

Percent Roadway Payment = (95 + 100)/2 = 97.5 percent

**Total Payment**

The percent payment for the Lot 105 is the lowest value of the percent payments for plant acceptance (98.8) and roadway acceptance (97.5), which is 97.5 percent.

All calculations for percent payment shall be rounded to the nearest 0.1 percent.

The payment adjustments for asphalt cement properties will stand-alone and will not be used in the individual lot calculations.

## DEFINITION OF A LOT

Subsection 508.11 of the *Standard Specifications* defines a standard lot for SMA at 5000 tons with five (5) 1000-ton sublots.

When a plant produces mixture for only one project, the lot size and the tonnage delivered to the project will be identical. But, when a plant produces the same mixture for multiple projects, portions of each lot will be allocated to each project. Under the latter circumstances, the term lot will refer to that portion of the standard lot delivered to each project.

A standard lot is 5000 tons of consecutive production of hot-mix asphalt from the same job mix formula produced for the department at an individual plant. A sublot is 1000 tons. However, minor adjustments will be made in the 1000-ton sublot size to accommodate hauling unit capacity. When the total lot quantity is expended in the partial load of a truck, the full legal load of the truck will be included in the sublot. For example, if 988 tons of HMA are produced and sent to a project and the next truck hauls 24 tons, the actual sublot size will be 1012 tons (998 + 24).

All newly certified plants will begin production at standard lot size (5000 tons). However, when historical records indicate that an acceptable and uniform hot-mix is continuously being produced, **the standard lot size may be increased when agreed upon by the district laboratory engineer and the contractor/producer**. Should the contractor/producer desire an increase in lot size then he/she should request this increase in writing to the attention of the district laboratory engineer. Once the expanded lot size has been established, it must be adhered to on a continuous basis. Lot sizes should not be expanded beyond the plant's average, normal daily production rate. It is not intended that lot sizes be frequently and arbitrarily increased or decreased to meet short-term production changes. If the mixture being produced during the expanded-size lot operations, does not meet department criteria or shows evidence or non-uniformity, the district laboratory engineer reserves the right to unilaterally reduce the expanded lot back to the standard 5000-ton size. In addition, the expanded lot may be reduced to the standard 5000-ton size at any time by mutual agreement of the district laboratory engineer and the contractor/producer.

The sublot and lot number shall be indicated on each haul ticket. (The sublot and lot number may be either printed on the ticket via the printer system or written on the DOTD stamped form on the back of the ticket.)

The QC technician and DOTD inspector shall keep a running total of production to ensure that all sublots and lots are terminated at proper tonnage and that the succeeding lot number is placed on the next haul ticket. Lot numbers will be assigned based on total tons of plant production for a JMF. Lot numbers will be sequential to plant production for DOTD without regard to delivery points, individual projects, or mix types. Therefore, lot numbers for an individual project could start at lot number 001 or at any lot number thereafter and will not necessarily be sequential on a project. Sublot numbers will be designated with letters (e.g., Lot 105-C would represent the third sublot in lot 105).

The QC technician and DOTD inspector shall also maintain a written log of the distribution of hot-mix production for DOTD projects from a plant's operation. This log is to be kept in a numbered field book and shall contain, as a minimum, the following data:

| Sublot No. | Date | Project No. | Tons | Mix Type/ Use | P. E. | Remark s | JMF | % AC/Gmm | Initials |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| **105-A** | **14 Aug** | **123-44-5678** | **1015.66** | **25/01** | **I. Doe** | **Tickets: 23-64** | **25.003** | **5.5% 2.503** | **C.V.J.** |
| **105-B** | **15 Aug** | **123-44-5678** | **1021.56** | **25/01** | **I. Doe** | **Tickets: 65-105** | **25.003** | **5.5% 2.505** | **C.V.J.** |
| **105-C** | **16 Aug** | **123-44-5678** | **1006.70** | **25/01** | **I. Doe** | **Tickets: 106-147** | **25.003** | **5.5% 2.506** | **C.V.J.** |
| **105-D** | **17 Aug** | **123-44-5678** | **1014.67** | **25/01** | **I. Doe** | **Tickets: 148-200** | **25.003** | **5.5% 2.502** | **C.V.J.** |
| **105-E** | **20 Aug** | **123-44-5678** | **1019.95** | **25/01** | **I. Doe** | **Tickets: 201-243** | **25.003** | **5.5% 2.505** | **C.V.J.** |
| | | **Lot Total:** | **5078.54** | | | | | | |
| | | | | | | | | | |
| **------------Control Charts are Up-To-Date ----------** | | | | | | | | | |

This log is to remain at the plant as a continuing record of plant production and distribution. It is to be maintained separately from all other department documentation. Notation shall also be made in the book to confirm that the QC Charts are current. Lot numbers shall not be repeated until the plant has produced 999 lots.

The lab engineer or the contractor/producer may decide upon a smaller lot size based on any of the following conditions:

- The total interval between continuous productions exceeds 2 days. This may include, but is not limited to, mechanical malfunction or inclement weather.

- A new job mix formula is approved and used. When an approved JMF proposal is used, the previous lot will be terminated at existing tonnage.

- Final Lot - The quantity of HMA needed to complete the project is smaller than the lot size (e.g., the final lot is less than the lot size).

- A payment adjustment will be applied to the portion of the lot already produced, provided plant adjustments have been made to bring the HMA into compliance with the specifications and the JMF.

**In the event of a smaller lot size, the HMA shall be accepted on the average values of the tests performed. It is not the department's intent that this specification be used to artificially manipulate the size of lots that will be assessed payment adjustments.**

**The final sublot on a project may be increased to within 150 percent of the stipulated plant sublot size. For example, if a plant were operating with 1000 tons sublots and the actual tonnage required to complete the project or phase following production for the second to last sublot is 1457, then the last sublot for the project would have 1457 tons. If the actual tonnage required to complete the**

**project is 1550, then two sublots would be required; one with approximately 1000 tons and one with 550 tons (adjusted for actual truck weights).**

**Application of a Lot Portion to Paving Operations** – It is noted that the number of days required to produce a lot is not significant. A lot may cover more than one day's operation. The lot number shall be assigned based on plant production. When mixture from a single lot is being delivered to more than one project, the tonnage for each individual project will be less than total lot tons. The applicable lot number will be used for each portion of the lot delivered to the projects.

The DOTD Certified Paving Inspector will be responsible for coordinating the results of roadway tests (pavement density and surface tolerance) for each lot with the results of plant tests for that lot. The station limits per lane of each lot, as well as the total number of tons from each lots must be documented in both the project field book and the Pavement Report (Appendix AD).

**Tests run on material sampled at the plant will affect all projects receiving mix from the lot. Tests run on material sampled at the roadway will affect only the individual project. Pavement density (cores) and surface tolerance (on the final roadway or airport wearing course) will cause payment adjustments on the individual project. Gradation (No. 8 and No. 200 sieves), $V_a$ and VMA, as well as asphalt cement acceptance and the incorporation of the JMF required percentage of anti-strip, will affect all projects receiving HMA from a lot. Payment adjustments, if necessary, per project, will be based on both plant and roadway tests. Therefore, the roadway must use the same lot number as the plant for the portion of a lot placed on that project. This procedure will normally result in non-sequential lot numbers at the roadway.**

An example of applying HMA materials to specific lots delivered to several projects simultaneously follows:

A plant is producing SMA Level I (1/2-inch NMS) Wearing Course HMA for three projects.

| | | | |
|---|---|---|---|
| Lot 105-A | = | 1010 | tons |
| | | 506 | tons to Project A |
| | | 463 | tons to Project B |
| | | 41 | tons to Project C |
| Lot 105-B | = | 1020 | tons |
| | | 710 | tons to Project A |
| | | 310 | tons to Project B |
| | | 0 | tons to Project C |
| Lot 105-C | = | 1008 | tons |
| | | 406 | tons to Project A |
| | | 292 | tons to Project B |
| | | 310 | tons to Project C |

Project A would show 506 tons matched to sublot 105-A, 710 tons to sublot 105-B and 406 tons to sublot 105-C.

Project B would show 463 tons matched to sublot 105-A, 310 tons to sublot 105-B and 292 tons to sublot 105-C.

Project C would show 41 tons matched to sublot 105-A, no tons to sublot 105-B and 310 tons to sublot 105-C. Under no circumstances would Project C, in this example, use the sublot number designation 105-B.

This HMA mix distribution shall be documented, on a daily basis, in the Plant Log Field Book as previously described.

## SMA COMPACTION AND MTV REQUIREMENTS

The SMA mixture shall be rolled immediately after placement. Two breakdown rollers capable of rolling across the width of the mat in one pass are recommended. Rolling shall be accomplished with steel wheel rollers weighing a minimum of 10 tons. Pneumatic rollers shall not be used. Vibratory rollers shall be limited to high frequency and low amplitude and used only as necessary to achieve density. The mastic shall not be allowed to migrate to the surface. Rolling shall continue until all roller marks are eliminated and minimum density is obtained (94 percent of $G_{mm}$ for travel lanes and 92% of $G_{mm}$ for shoulders), but not after the mat has cooled to 220°F or lower. Traffic shall not be placed on the newly compacted surface until the mat has cooled to 140°F or lower. It is recommended that paver speed not exceed 25 feet per minute.

The MTV shall be required for placing all SMA materials.

## PROVISIONS FOR SMALL QUANTITIES

**Less than 250 tons of SMA** – For projects, or separate locations within a project, requiring less than 250 tons (250 Mg), the job mix formula, materials, and plant and paving operations shall be satisfactory to the engineer. The engineer may modify the sampling and testing requirements for surface tolerance and pavement density and waive the payment adjustments for deviations.

For projects, or separate locations within a project, requiring between 250 and 1000 tons (250 and 1000 Mg) of mixture, the acceptance and quality control testing will be the same as for one sublot within a lot. This one set of deviations from the JMF, not the *average* deviations, will determine the pay as per Table 508-1 and Table 508-2.

If the final number of sublots for a project lot is less than five, or if the total number of sublots for a project is less than five, each sublot shall be tested for acceptance and quality control, The average of the deviations from JMF acceptance values will determine pay as per Table 508-1 and 508-2.

## SUMMARY OF DOCUMENTATION

**Asphaltic Concrete Plant Certification Report** – The Asphaltic Concrete Plant Certification Report (Appendix A) is used to inspect the HMA plant for certification. In addition, a copy of the completed form is used for the 90-day inspections or intermediate inspections that are directed by the district laboratory engineer. An authorized representative of the district laboratory engineer completes this form. Two copies of this form are completed. One copy is kept at the plant in the Plant Certification File. The other copy is forwarded to the district laboratory engineer.

**Certification Report for Scales and Meters** – This form will be provided by the department and can be obtained, along with all other DOTD documents, from the district laboratory engineer. This form is to be completed by an authorized representative of an independent scale calibration company (hired by the contractor/producer) and submitted to the district laboratory engineer. This form, whether completed for initial plant certification or for subsequent 90-day checks, shall be prepared in duplicate. One copy shall be retained in the Plant Certification File at the plan; the other is to be forwarded to the district laboratory engineer.

**Asphaltic Concrete Paving Equipment Certification** – District laboratory representatives use the Asphaltic Concrete Paving Equipment Certification form (Appendices E, F and G) to document the certification of asphalt distributors, pavers, and rollers. This form is designed to be used as a complete package to certify the entire paving train or in parts for the certification of individual pieces of equipment. Copies of the certification forms for each piece of equipment certified in the district will be furnished to each project engineer in the district. Copies of equipment certification documentation will be supplied across district lines, upon request, to the certifying district laboratory engineer.

**Asphaltic Concrete Paving Equipment Checklist** – This form (Appendix I) is to be used by project personnel (Certified Paving Inspectors) at the beginning of each project to document that all paving equipment used on the project (except for projects with less than 1000 tons or for a project with less than 1000 tons on separate areas within the project) is certified and is operating in accordance with the standards under which certification was granted. Copies of these checklists shall be placed in the 2059 Review for the project on which the equipment was in operation.

This form is also to be used by the district laboratory representatives to document the ninety-day review inspections of certified equipment. It will be kept on file at the district laboratory with the original certification form and will be furnished to each project engineer within the district on a routine basis. Copies will also be made available across district lines, upon request, to the certifying district laboratory engineer.

**Asphaltic Concrete Paving Miscellaneous Equipment Checklist** – This form (Appendix J) is to be used as a checklist by the Certified Paving Inspector to be certain that all miscellaneous equipment is available on the project and is in acceptable condition. It will also be included in the 2059 Review.

**Job Mix Proposal (Release Form)** – In order to submit a job mix formula to the department for approval, the QC technician must complete the Asphaltic Concrete Job Mix Release form (Appendix Y for Marshall or AK for Superpave) (an approved computer generated form similar to the DOTD form may be used) along with other design data. The following design data is required:

1. A proposed blend summary with gradations and volumetrics at optimum proposed optimum asphalt cement content.

2. A plot of proposed composite gradation on the ½-inch NMS 0.45 power curve.

3. A quantitative summary of three (minimum) trial blends.

4. Marshall Design - Optimum asphalt cement content summary for ($V_a$, VMA, VFA, Marshall stability and flow).

5. Superpave Gyratory Compactor Design - Optimum asphalt cement content summary for ($V_a$, VMA, VFA, and % $G_{mm}$ @ $N_{initial}$).

6. Fine aggregate angularity (FAA) results –TR 121

7. Moisture sensitivity results – AASHTO T 283.

The QC technician shall enter the proposed mix design data on the JMF Release form and sign and date the form in the space labeled "Submitted for the Contractor by." The technician shall then submit the form to the district laboratory engineer for initial approval.

The district laboratory engineer will check all submitted information and attached design information. If any information is incorrect the district laboratory engineer will return the proposed JMF Release to the QC technician. If all information is correct and meets specifications, then the district laboratory engineer will assign the sequence number, mark the form approved, sign and date it on the line labeled "Proposal Approved," and return the approved proposal to the QC technician. The plant will then be able to begin production for DOTD project for validation purposes.

Prior to the **validation process,** as is the case prior to sending any HMA mixture to a DOTD project, the QC technician shall forward a copy of the proposed JMF, either validated or disapproved, to the project engineer in charge of the project receiving HMA materials. A facsimile copy will suffice.

If the JMF is disapproved, the district laboratory engineer will mark the form disapproved, enter the MATT laboratory submitter code, sign and date the form, then return it to the QC technician and the project engineer in charge of the project for which HMA material is being supplied. If the district laboratory engineer disapproves the JMF Release, the QC technician must submit a new JMF Release proposal. No additional mixture can be produced for DOTD projects until the district laboratory engineer approves a new JMF Release proposal for validation.

If the JMF is approved, the district laboratory engineer will mark the form approved, enter the MATT System Submitter Code, sign (in the space labeled “Approved”) and date the form, then return it to the QC technician and the project engineer in charge of the project for which HMA material is being supplied. If the district laboratory engineer approves the JMF Release, the plant can continue operations for DOTD projects having the same specification requirements as the mix design. The mix design will be approved for separate projects on an individual basis.

Following validation, the JMF Release must be assigned to those projects which receive mix produced from the JMF. After the project engineers, in charge of the project(s) receiving HMA materials receives the JMF for specification conformity, the project engineer will complete the header information and enter the date first used on the project. The project engineer will also sign the form in the space labeled “Approved for Project by” and forward the copy to the district laboratory engineer.

The district laboratory engineer will then distribute copies of the JMF Release to the project engineer, the QC Certified Technician, the Materials Engineer Administrator, and the Construction Audit Unit.

Once a JMF has been validated and approved, it may be used for other projects having the same specification requirements. The contractor/producer will request the use of this mixture design from the project engineer in charge of the project receiving HMA mixture. The project engineer will ensure that all specification and contract requirements applying to the project for which the mix is intended will be met by the previously approved design.

**Asphaltic Concrete Gradation – 0.45 Power Curve** – The QC technician shall plot the proposed design gradation on the appropriate 0.45 Power Curve according the mixture’s nominal maximum aggregate size (1/2-inch NMS) (Appendix T). This gradation plot must accompany the JMF Release when submitted to the district laboratory engineer for initial approval. A computer generated gradation plot may be used in lieu of the DOTD supplied form.

**Optimum Asphalt Cement Content – Summary of Test Properties** – – The QC certified technician shall submit the Summary of Test Properties form (Appendix W or AP) along with the JMF Release form and supporting design data to the district laboratory engineer. A computer generated Summary of Test Properties form may be used in lieu of the DOTD supplied form. Plots of $V_a$, VMA, VFA, Marshall Stability, and flow shall be graphed versus percent asphalt cement as determined from the trial blends. For Superpave Gyratory Compactor designs, percent $G_{mm}$ @ $N_{initial}$ is substituted for stability and flow values.

**Tensile Strength Ratio (TSR)** The QC technician submits the Tensile Strength Ratio (TSR) form (Appendix X) to the district laboratory engineer, along with the JMF Release form and supporting design data. An approved computer generated TSR form may be used in lieu of the DOTD supplied form. Careful attention should be made to the calculations required in accordance with AASHTO T 283, for degree of saturation.

**Asphaltic Concrete Plant Report** – The Asphaltic Concrete Plant Report (Appendix AB for Marshall or AW for Superpave) is a MATT System form. It is to be completed based on plant sublot and lot. Space has been allotted on the form for five individual projects, since the results of plant testing per lot will apply to each project receiving HMA mixtures from the lot. Therefore, it is imperative that each project to which mix is delivered from a lot be recorded on the form. It is the joint responsibility of the contractor/producer technician, the DOTD inspector and the district laboratory to complete and sign this report.

The inspector sends the completed Plant Report to the district laboratory with the Asphaltic Concrete Verification Report (Appendix AE), the Marshall or gyratory briquettes (one per sublot) and roadway pavement cores (two per sublot) for verification testing. The Plant Report, when filed with the Pavement Report (Appendix AD), will complete documentation for acceptance of the HMA lot.

**The QC Certified Technician shall use a separate copy of this form (stamped with one-inch high letters "QC" in red ink) to record quality control testing for extracted gradation, percent asphalt cement and percent crushed aggregate. The QC gradation, percent asphalt cement, air voids ($V_a$) and maximum theoretical specific gravity of the paving mixture ($G_{mm}$), shall be plotted on the Asphaltic Concrete Control Charts.**

An original and one copy of each plant report must be completed for acceptance. The signed original shall be sent to the district laboratory. The copy shall be kept in the plant files. The district laboratory engineer's representative will review the information for completeness and accuracy and sign the form on the line labeled district laboratory. The district laboratory engineer will then review the information and approve the form by signing in the line labeled Approved By before the information is entered into the MATT System. The MATT System will then generate a logging report for each project. The district laboratory will keep the original of the Plant Report. Copies will be sent to each project engineer receiving mixture from the lot.

**Asphaltic Concrete Control Charts** – These charts shall be completed by the technician as testing is completed. They are to be maintained on a lot basis. **Control Charts shall be plotted for extracted aggregate gradation, extracted percent asphalt cement, air voids ($V_a$), and maximum theoretical gravity of the HMA mixture (G).** There is space for up to three entries per lot on each graph. Corrective action taken for deficiencies (or to bring the production process closer to median values) shall be documented, dated and initialed on the back of the Control Chart by the QC Certified Technician. The control charts are to be kept at the plant. A copy of the control charts is sent to the district laboratory at the end of each project. A copy of the DOTD control chart form is shown in Appendix AC. An approved computer-generated form may be used in lieu of the DOTD supplied form.

**Pavement Report** – The Asphaltic Concrete Pavement Report form (Appendix AD) **will be completed for each mix use for each type mix for each project**. This will result in only one pay item being recorded on each form. The DOTD Certified Paving Inspector is responsible for the completion of this form, with the exception of roadway density data and corresponding percent pay information that is determined at the plant. The DOTD Certified Plant Inspector will complete these sections. The DOTD Certified Paving

Inspector will sign and date the form in the space labeled "Roadway Inspector." The Pavement Report, when filed in conjunction with the Asphaltic Concrete Plant Report, will complete documentation for acceptance of the pavement lot.

An original plus two copies, of the pavement report must be generated. The DOTD Certified Paving Inspector for project records will keep one copy. The original and one copy are to be sent to the DOTD Certified Plant Technician with each set of pavement cores. The DOTD Certified Plant Technician will complete both copies of the form with pavement density information and percent pay, then sign and date the form on the line labeled "Plant Inspector." The original will then be sent to the district laboratory; the other completed copy will be retained for plant files. A district laboratory engineer representative, upon receipt, will review the form for completeness and accuracy, initial and date it in the upper right corner, enter the information into the MATT System, and copy the form for use during verification testing. The original will then be sent the project engineer receiving mixture for the lot for approval, signature, project records and 2059 submittal.

Any disposition of failing results or payment adjustments must be noted in the "Remarks Field" by the project engineer and returned to the district laboratory engineer for MATT System update. The district laboratory will then update the MATT System, copy the updated Asphaltic Concrete Pavement Report for laboratory files, and then return the original to the project engineer. The district laboratory will keep a copy of the updated report in the Disposition of Failing Test Reports file.

**Asphaltic Concrete Verification Report** – The district laboratory uses this form (Appendix AE) to report the results of Independent Assurance and verification tests on samples submitted by project personnel.

The DOTD Certified Plant Inspector will complete an original and one copy of the Verification Report. The original will be attached to the Marshall or Superpave gyratory briquettes, which are submitted to the district laboratory for verification testing. Before sending the form to the district laboratory with the briquettes, the inspector will enter the "Header" information and sample ID for the volumetric tests along with the $G_{mm}$ determined for the corresponding sublot. All samples ID's will consist of the lot number plus sample number as identified by the plant inspector or the paving inspector. The Verification Report and briquettes are to be sent to the district laboratory along with Asphaltic Concrete Plant Report.

The DOTD Certified Paving Inspector will complete an original and two copies of the Verification Report for each set of pavement samples sent to the plant for acceptance and testing. The original and one copy of the report must accompany the samples. The paving inspector will retain the second copy for project records. The paving inspector will complete the header information, Roadway Tests and Sample ID.

After completing plant tests on the pavement samples, the Certified Plant Inspector will forward the two of the five samples to the district laboratory for verification testing. All sample ID's shall consist of the sublot and lot number plus sample number. The inspector will then attach the original Verification Report to the original Pavement Report which accompanies the pavement samples to the district laboratory.

The district laboratory will use these forms (Plant and Roadway information) to enter complete verification information into the MATT System. The MATT System will then generate a single logging report for the project engineer's records. If problems are encountered during the verification process, copies of the Verification Report will be sent to the project engineer.

**Ticket for Hot-Mix Asphalt** – All quantities (truck loads) of SMA materials delivered to DOTD projects shall be recorded on printer tickets stamped on the back with the departmental Stamp.

This stamped printer ticket is given to the driver of the certified haul truck. The driver, upon arriving at the paving site, will turn over this ticket to the DOTD Paving Inspector. The paving inspector is responsible for completing and signing the lower portion of the stamp.

**Since lot numbers may not necessarily be sequential for a specific project, it is imperative that the number assigned to each ticket be sequential for each project for each mixture type. This number will include both lot number and sequential project ticket number.**

As a minimum, the HMA ticket shall show the following information:

- Project Number
- Date
- Sublot and Lot Number
- Ticket Number
- Truck Number (DOTD Certification Number for truck)
- Mix Type